Rocky Mountain Rail Authority (RMRA)

Corridor Input Team Meeting #3

Alternatives Evaluation

April 29 & 30, 2009

DRCOG, Denver

Silverthorne Library, Silverthorne

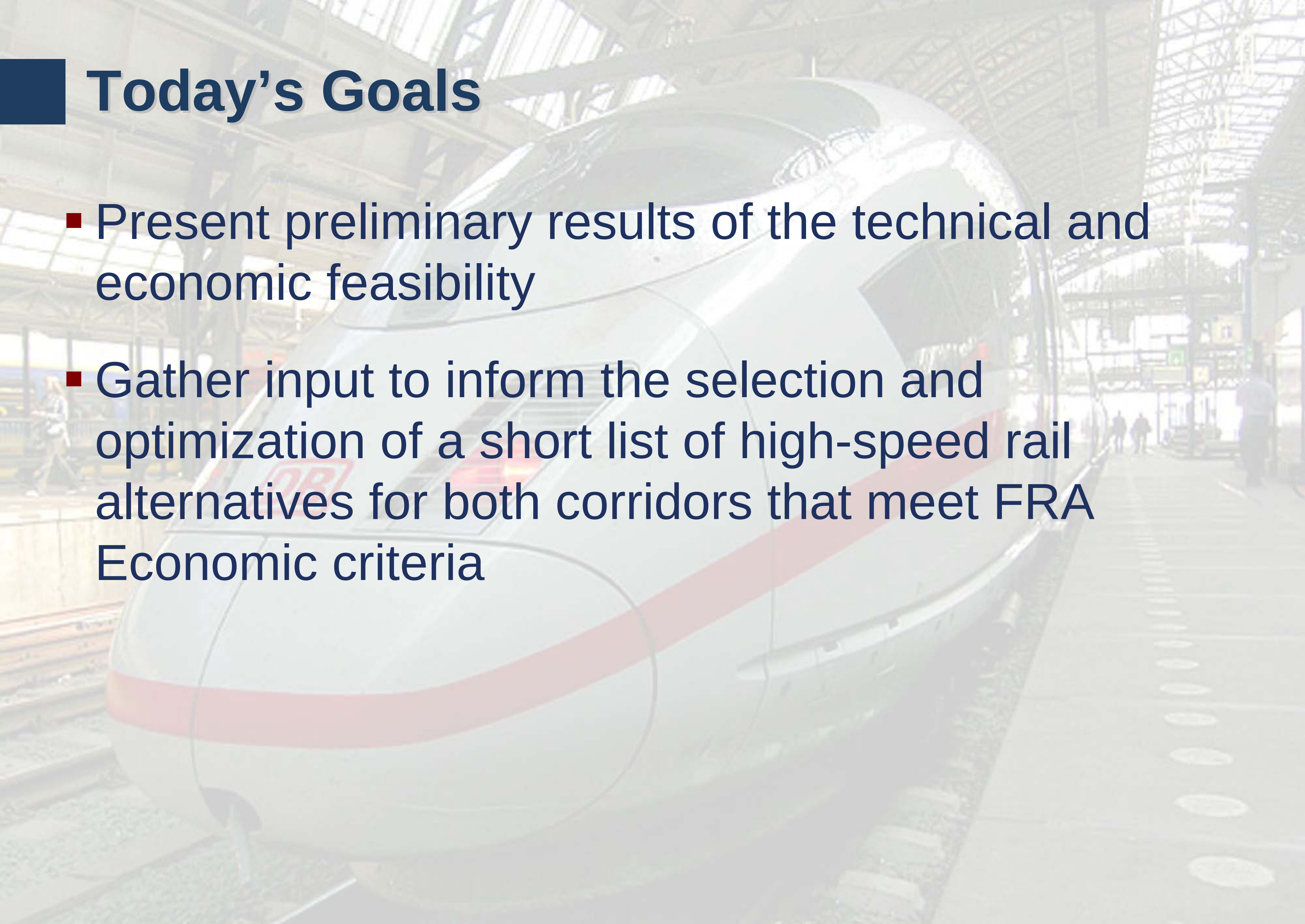
North Front Range MPO, Fort Collins
PPACG, Colorado Springs

High Speed Rail Feasibility Study

TEMS, Inc. / Quandel Consultants, LLC

Agenda

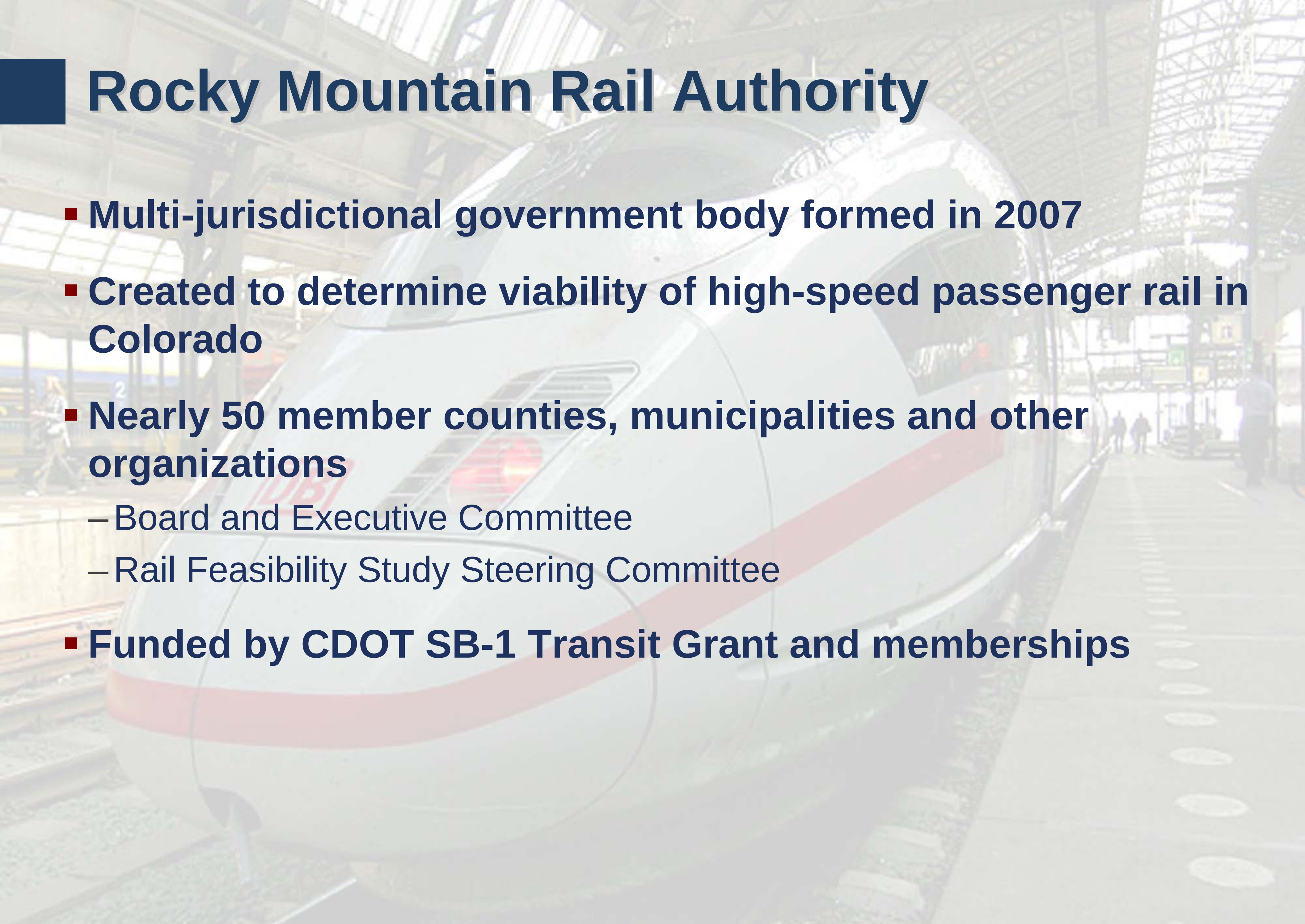
- **Introductions**
- **Study Overview**
- **Alternatives Overview**
- **Evaluation Criteria & Capital Costing Considerations**
- **Preliminary Results**
  - – Ridership and Revenue
  - – Capital Costs
  - – Operations & Operating Costs
  - – Financial & Economic Analysis
- **Discussion and Input**



Today’s Goals

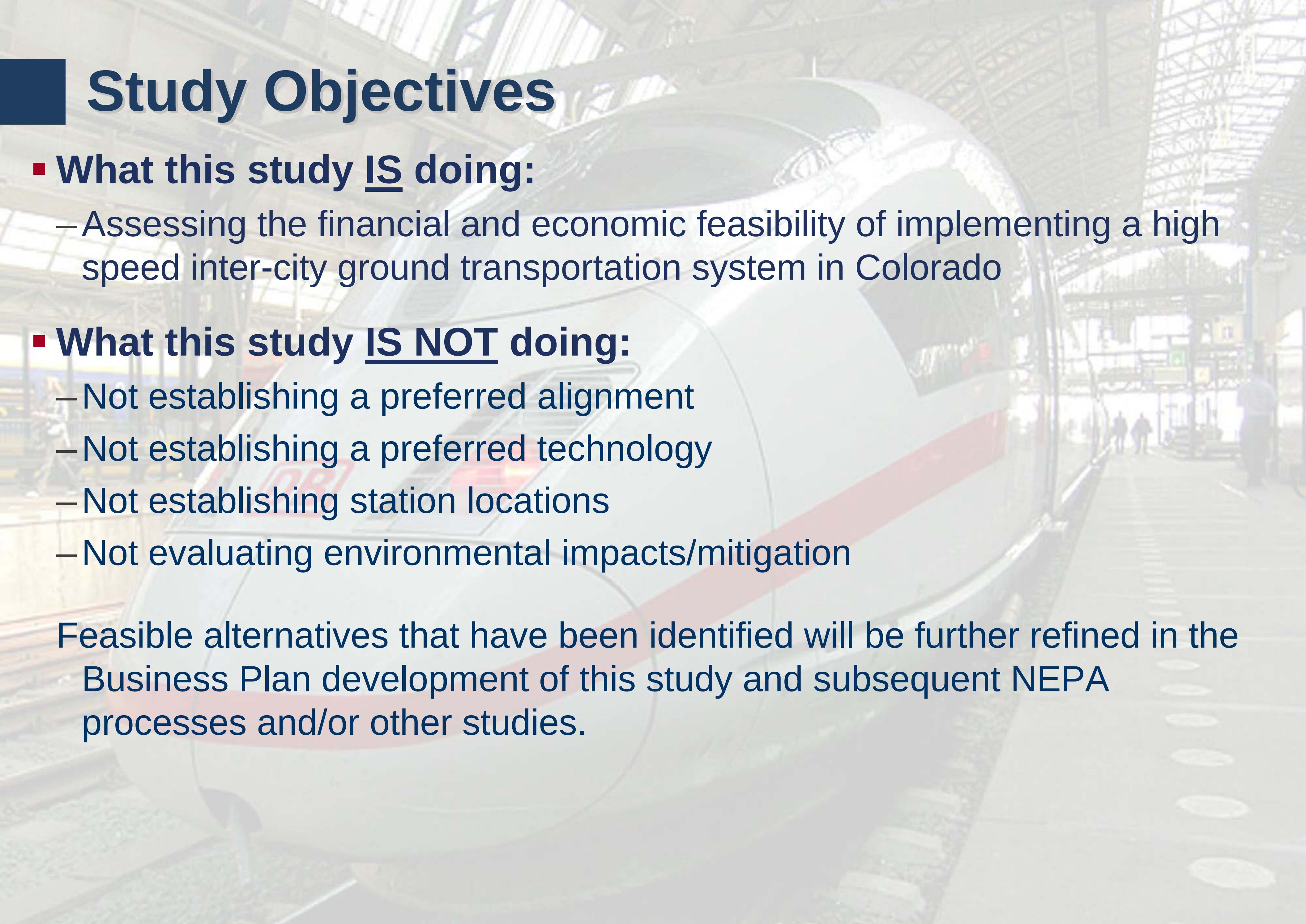
- Present preliminary results of the technical and economic feasibility
- Gather input to inform the selection and optimization of a short list of high-speed rail alternatives for both corridors that meet FRA Economic criteria

Study Overview



Rocky Mountain Rail Authority

- **Multi-jurisdictional government body formed in 2007**
- **Created to determine viability of high-speed passenger rail in Colorado**
- **Nearly 50 member counties, municipalities and other organizations**
  - Board and Executive Committee
  - Rail Feasibility Study Steering Committee
- **Funded by CDOT SB-1 Transit Grant and memberships**

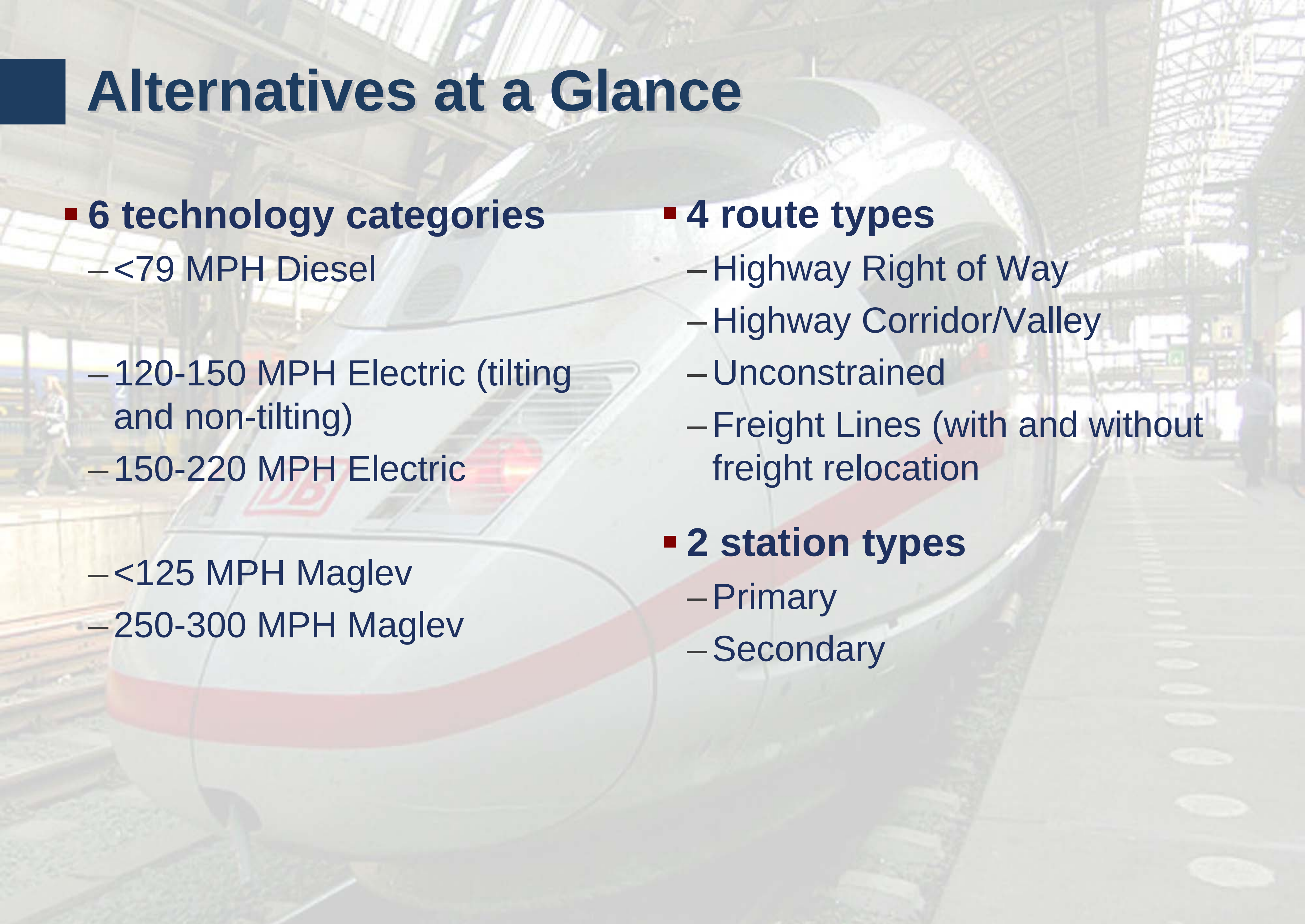


Study Objectives

- **What this study IS doing:**
  - Assessing the financial and economic feasibility of implementing a high speed inter-city ground transportation system in Colorado
- **What this study IS NOT doing:**
  - Not establishing a preferred alignment
  - Not establishing a preferred technology
  - Not establishing station locations
  - Not evaluating environmental impacts/mitigation

Feasible alternatives that have been identified will be further refined in the Business Plan development of this study and subsequent NEPA processes and/or other studies.

Alternatives Overview



Alternatives at a Glance

- **6 technology categories**
  - <79 MPH Diesel
  - 120-150 MPH Electric (tilting and non-tilting)
  - 150-220 MPH Electric
  - <125 MPH Maglev
  - 250-300 MPH Maglev

- **4 route types**
  - Highway Right of Way
  - Highway Corridor/Valley
  - Unconstrained
  - Freight Lines (with and without freight relocation

- **2 station types**
  - Primary
  - Secondary

Proposed Preliminary Scenarios

Corridor	I-25 North Wyoming Border to North Suburban Station	I-25 South New Mexico Border to South Suburban Station		I-70 East Golden to Avon	I-70 West Avon to Grand Junction
Alternative					
1					
1 (a)	Diesel, 79 mph Track Speed Existing Rail with R2C2*	Diesel, 79 mph Track Speed Existing Rail with R2C2		Not Applicable due to lack of power for gradients	Not Applicable due to lack of power for gradients
1 (b)	Diesel, 79 mph Track Speed Existing Rail, without R2C2	Diesel, 79 mph Track Speed Existing Rail, without R2C2		Not Applicable due to lack of power for gradients	Not Applicable due to lack of power for gradients
2					
2 (a)	Diesel, 110 mph Track Speed Existing Rail with R2C2	Diesel, 110 mph Track Speed Existing Rail with R2C2		Not Applicable due to lack of power for gradients	Not Applicable due to lack of power for gradients
2 (b)	Diesel, 110 mph Track Speed Existing Rail, without R2C2	Diesel, 110 mph Track Speed Existing Rail, without R2C2		Not Applicable due to lack of power for gradients	Not Applicable due to lack of power for gradients

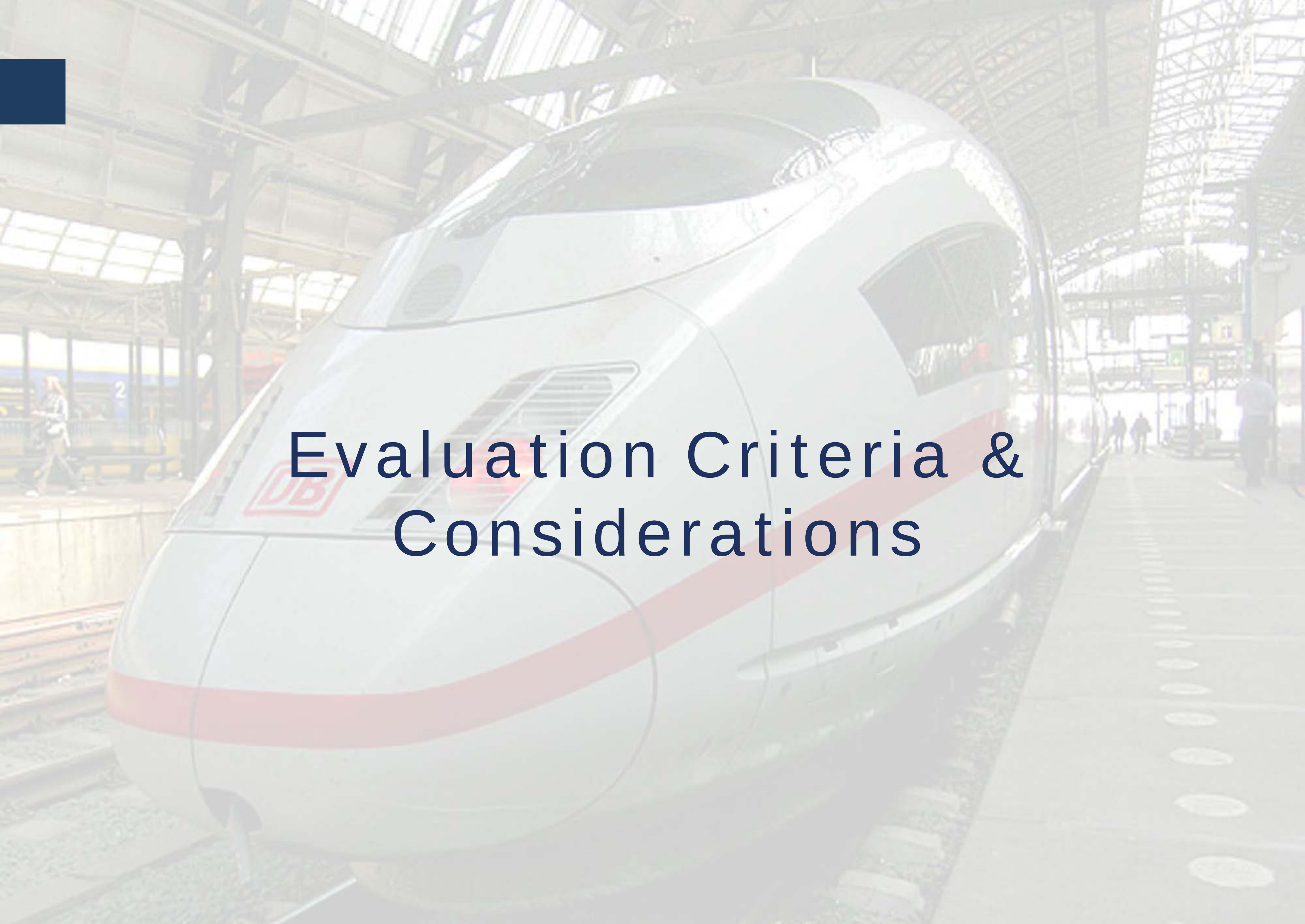
***R2C2 refers to CDOT's freight rail relocation study**

Proposed Preliminary Scenarios

Corridor	I-25 North Wyoming Border to North Suburban Station	I-25 South New Mexico Border to South Suburban Station		I-70 East Golden to Avon	I-70 West Avon to Grand Junction
Alternative					
3					
3(a)	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Highway Corridor Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Unconstrained Alignment		I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 R.O.W. Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 R.O.W. Alignment
3(b)	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Highway Corridor Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Unconstrained Alignment		I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 Highway Corridor Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 Highway Corridor Alignment
3 (c)	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Highway Corridor Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-25 Unconstrained Alignment		I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 Unconstrained Alignment	I-70 PEIS Advanced Guideway System Maglev, 125 mph Track Speed I-70 Unconstrained Alignment
4					
4	Electric, Locomotive Pulled 150 mph Track Speed Existing Rail, with R2C2	Electric, Locomotive Pulled 150 mph Track Speed Existing Rail, with R2C2		Electric, Locomotive Pulled 150 mph Track Speed I-70 Unconstrained Alignment	Electric, Locomotive Pulled 150 mph Track Speed I-70 Unconstrained Alignment

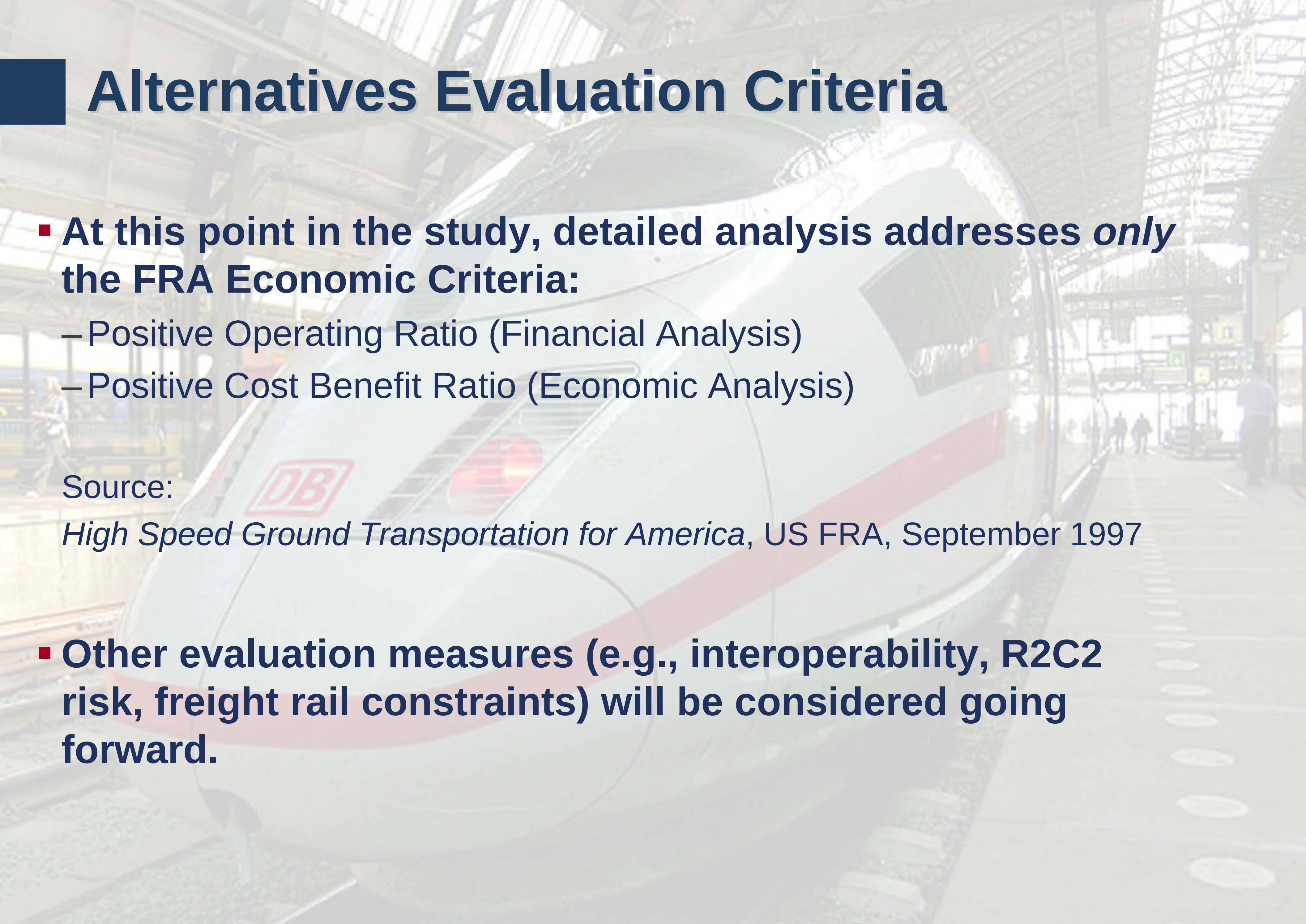
Proposed Preliminary Scenarios

Corridor	I-25 North Wyoming Border to North Suburban Station	I-25 South New Mexico Border to South Suburban Station		I-70 East Golden to Avon	I-70 West Avon to Grand Junction
Alternative					
5					
5(a)	I-70 PEIS Rail Alternative Electric, EMU Non Tilting 150 mph Track Speed I-25 Highway Corridor Alignment	I-70 PEIS Rail Alternative Electric, EMU Non Tilting Electric, 150 mph Track Speed I-25 Unconstrained Alignment		I-70 PEIS Rail Alternative Electric, EMU Non Tilting 150 mph Track Speed I-70 R.O.W. Alignment	I-70 PEIS Rail Alternative Electric, EMU Non Tilting 150 mph Track Speed I-70 R.O.W. Alignment
5 (b)	Electric, EMU Tilting 220 mph Track Speed I-25 Highway Corridor Alignment	Electric, EMU Tilting 220 mph Track Speed I-25 Unconstrained Alignment		Electric, EMU Tilting 220 mph Track Speed I-70 R.O.W. Alignment	Electric, EMU Tilting 220 mph Track Speed I-70 R.O.W. Alignment
5 (c)	Electric, EMU Tilting 220 mph Track Speed I-25 Highway Corridor Alignment	Electric, EMU Tilting 220 mph Track Speed I-25 Unconstrained Alignment		Electric, EMU Tilting 220 mph Track Speed I-70 Unconstrained Alignment	Electric, EMU Tilting 220 mph Track Speed I-70 Unconstrained Alignment
6					
6 (a)	Maglev, 300 mph Track Speed I-25 Highway Corridor Alignment	Maglev, 300 mph Track Speed I-25 Unconstrained Alignment		Maglev, 300 mph Track Speed I-70 Highway Corridor Alignment	Maglev, 300 mph Track Speed I-70 Highway Corridor Alignment
6 (b)	Maglev, 300 mph Track Speed I-25 Highway Corridor Alignment	Maglev, 300 mph Track Speed I-25 Unconstrained Alignment		Maglev, 300 mph Track Speed I-70 Unconstrained Alignment	Maglev, 300 mph Track Speed I-70 Unconstrained Alignment



Evaluation Criteria & Considerations

Alternatives Evaluation Criteria



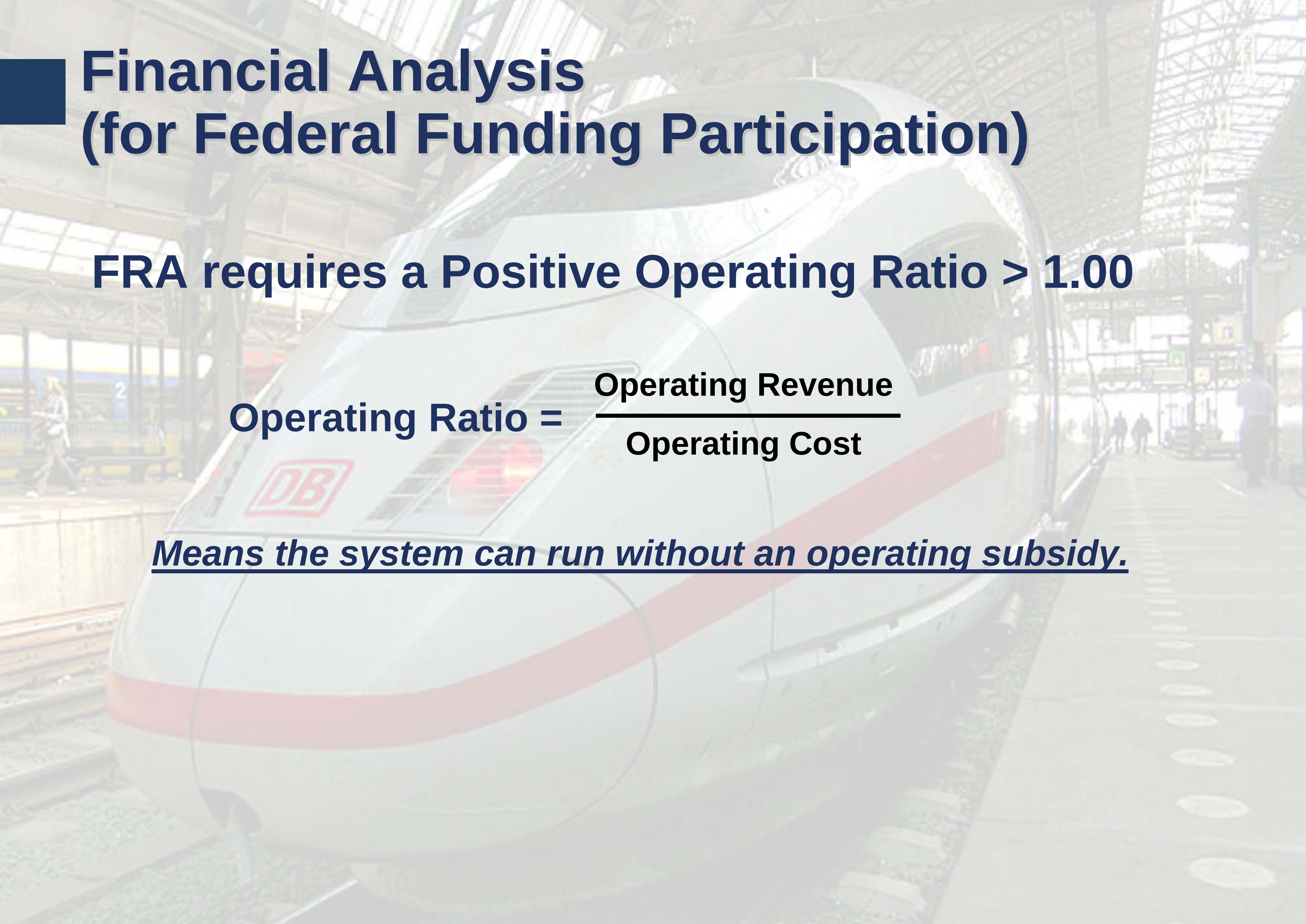
- **At this point in the study, detailed analysis addresses *only* the FRA Economic Criteria:**
  - Positive Operating Ratio (Financial Analysis)
  - Positive Cost Benefit Ratio (Economic Analysis)

Source:

High Speed Ground Transportation for America, US FRA, September 1997

- **Other evaluation measures (e.g., interoperability, R2C2 risk, freight rail constraints) will be considered going forward.**

Financial Analysis (for Federal Funding Participation)

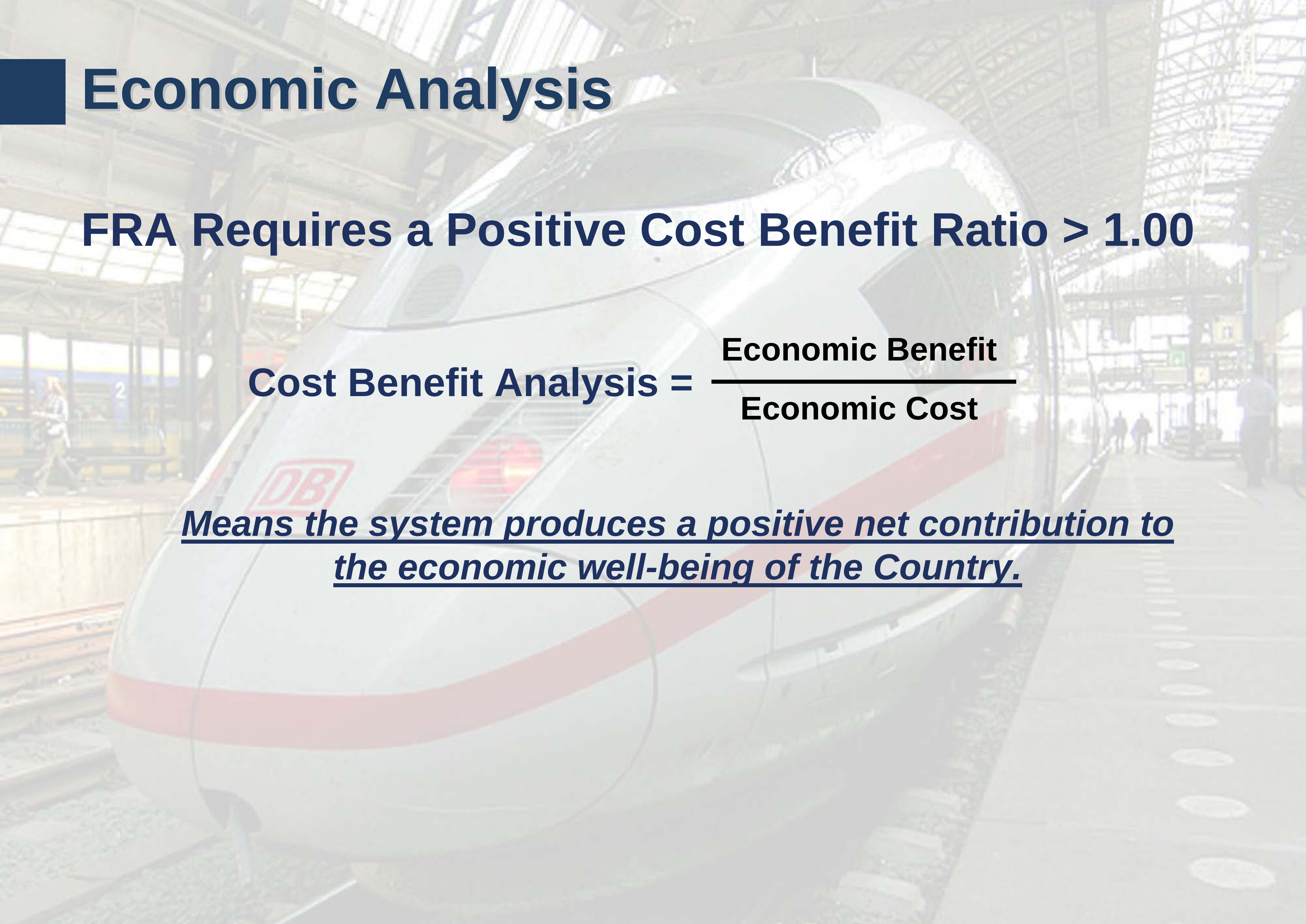


FRA requires a Positive Operating Ratio > 1.00

$$\text{Operating Ratio} = \frac{\text{Operating Revenue}}{\text{Operating Cost}}$$

Means the system can run without an operating subsidy.

Economic Analysis



FRA Requires a Positive Cost Benefit Ratio > 1.00

$$\text{Cost Benefit Analysis} = \frac{\text{Economic Benefit}}{\text{Economic Cost}}$$

Means the system produces a positive net contribution to the economic well-being of the Country.

Example Cost Benefit Analysis (MWRRS)

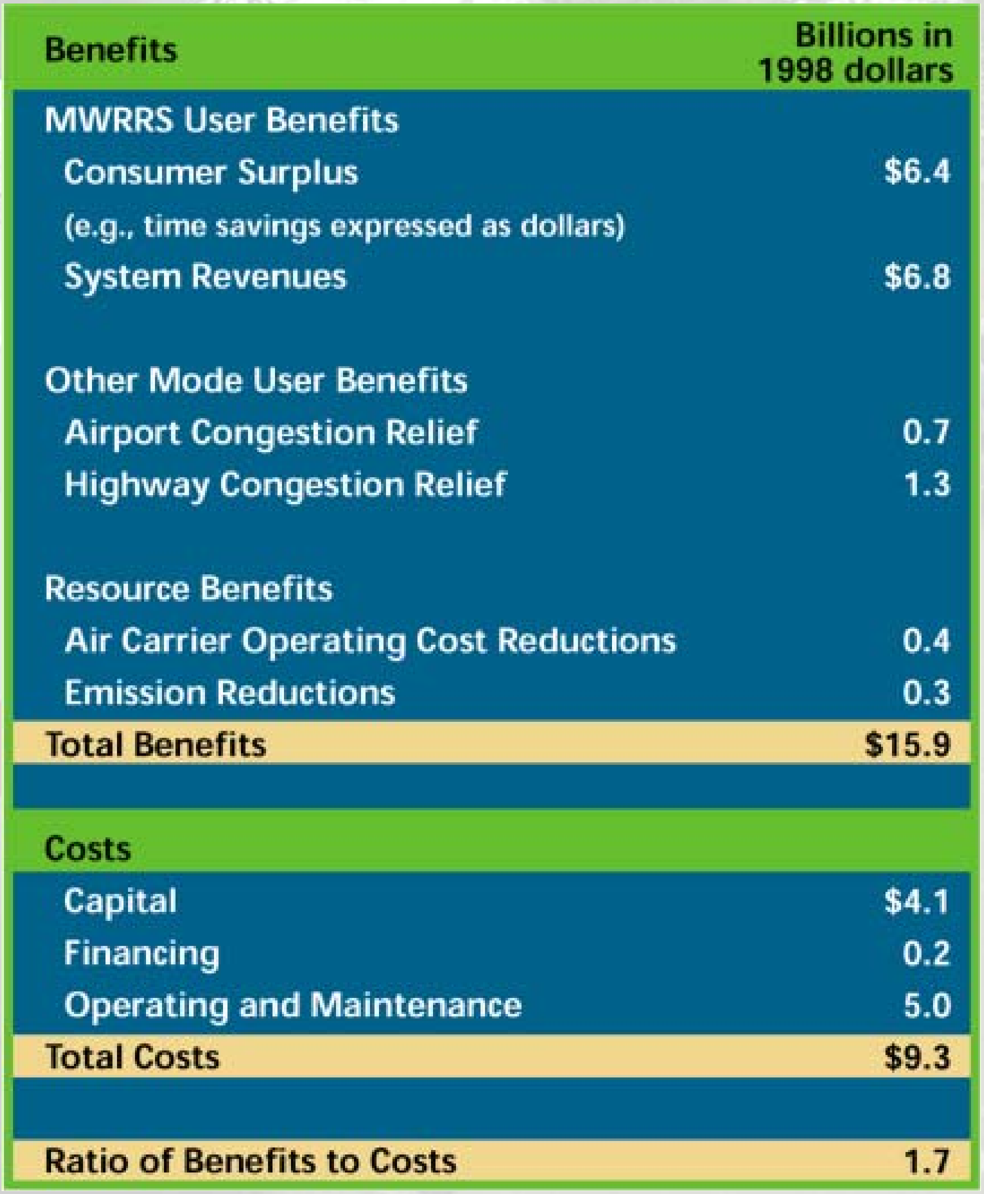
- **Positive Operating Ratio**

Present Value Revenue /
Present Value Operating Costs
6.8 / 5.0 = 1.36

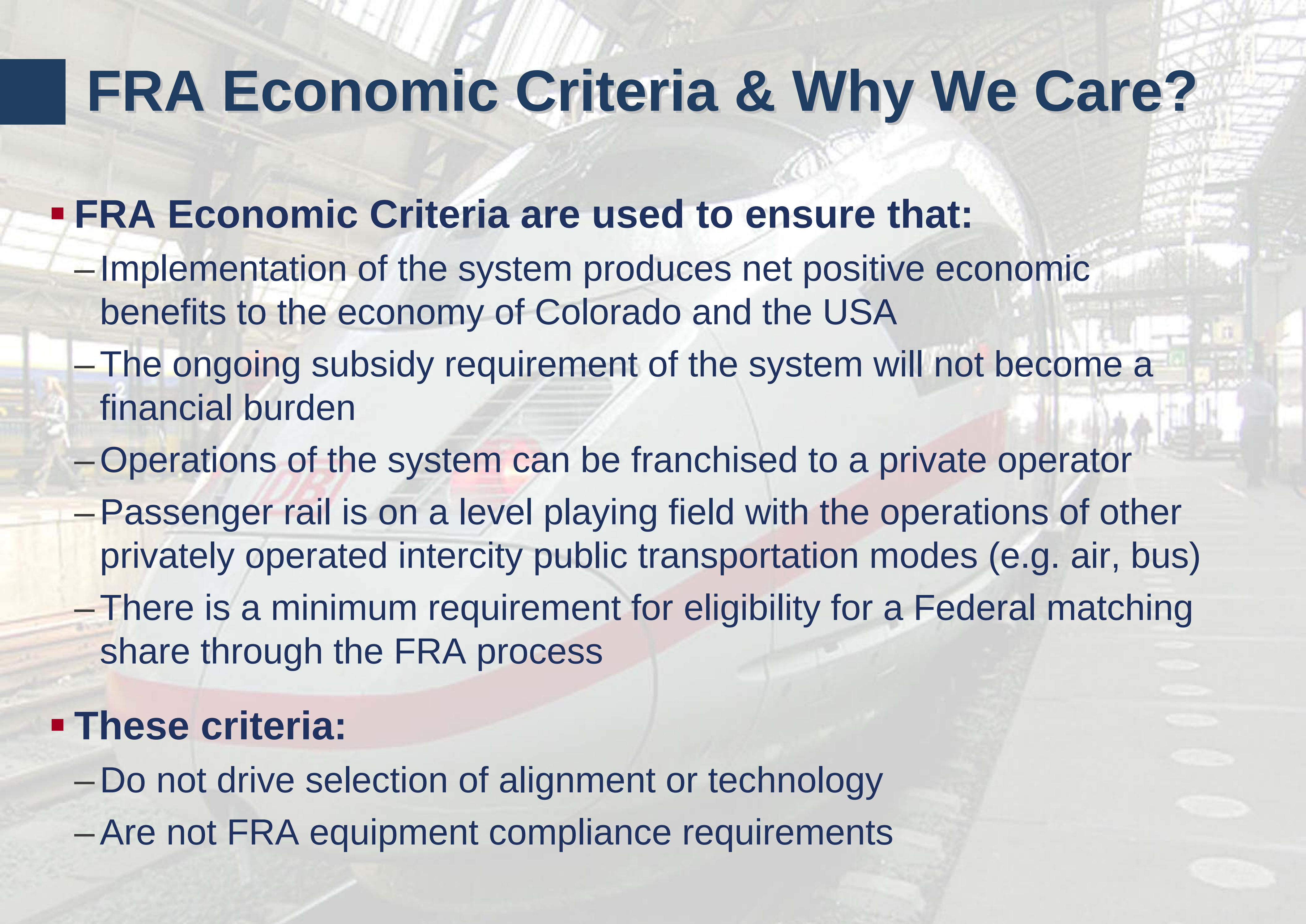
- **Positive Cost Benefit Ratio**

Present Value Benefits /
Present Value Total Costs
15.9 / 9.3 = 1.71

***Present Value = Conversion of future dollars to current dollars**



Benefits	Billions in 1998 dollars
MWRRS User Benefits	
Consumer Surplus	$6.4
(e.g., time savings expressed as dollars)	
System Revenues	$6.8
Other Mode User Benefits	
Airport Congestion Relief	0.7
Highway Congestion Relief	1.3
Resource Benefits	
Air Carrier Operating Cost Reductions	0.4
Emission Reductions	0.3
Total Benefits	**$15.9**
Costs	
Capital	$4.1
Financing	0.2
Operating and Maintenance	5.0
Total Costs	**$9.3**
Ratio of Benefits to Costs	**1.7**

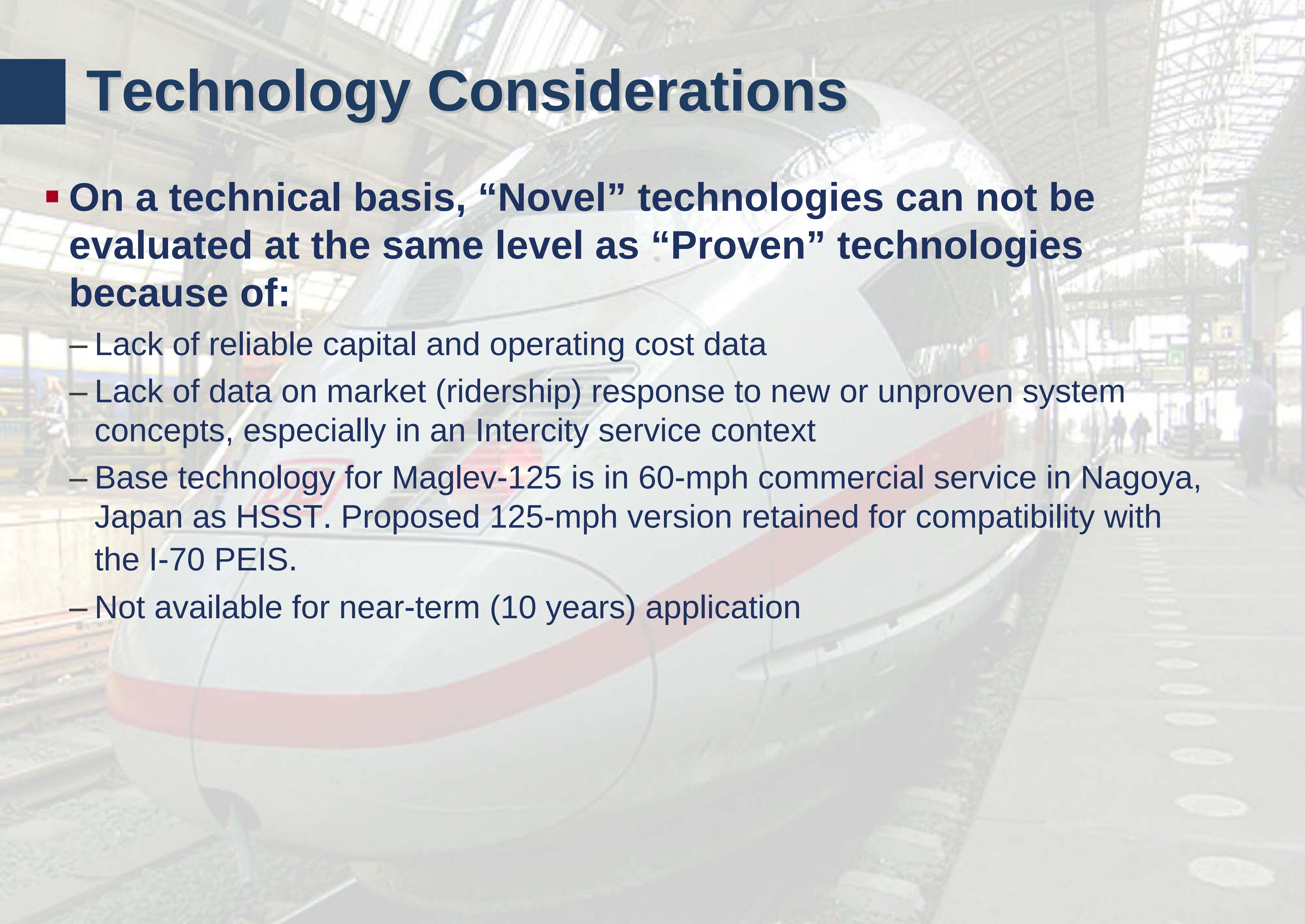


FRA Economic Criteria & Why We Care?

- **FRA Economic Criteria are used to ensure that:**
  - Implementation of the system produces net positive economic benefits to the economy of Colorado and the USA
  - The ongoing subsidy requirement of the system will not become a financial burden
  - Operations of the system can be franchised to a private operator
  - Passenger rail is on a level playing field with the operations of other privately operated intercity public transportation modes (e.g. air, bus)
  - There is a minimum requirement for eligibility for a Federal matching share through the FRA process
- **These criteria:**
  - Do not drive selection of alignment or technology
  - Are not FRA equipment compliance requirements

Technology Considerations

- **FRA compliance**
  - Non-compliant technologies are included in the current study.
  - Compliance is not just a “Buff Strength” issue but affects many aspects of the equipment design.
- **Transportability of technology**
  - It has been assumed that European and Asian equipment could be modified at reasonable cost to meet US and Colorado requirements
    - Capital costs are based on previous manufacturers’ quotes for FRA-compliant trainsets.
  - Notwithstanding the Acela precedent, a benchmarking analysis has suggested a weight penalty in the order of 10% for full FRA compliance.
    - This weight can likely be compensated by additional power, resulting in little, if any, net degradation to performance of the train.



Technology Considerations

- **On a technical basis, “Novel” technologies can not be evaluated at the same level as “Proven” technologies because of:**
  - Lack of reliable capital and operating cost data
  - Lack of data on market (ridership) response to new or unproven system concepts, especially in an Intercity service context
  - Base technology for Maglev-125 is in 60-mph commercial service in Nagoya, Japan as HSST. Proposed 125-mph version retained for compatibility with the I-70 PEIS.
  - Not available for near-term (10 years) application

Freight Rail Right of Way

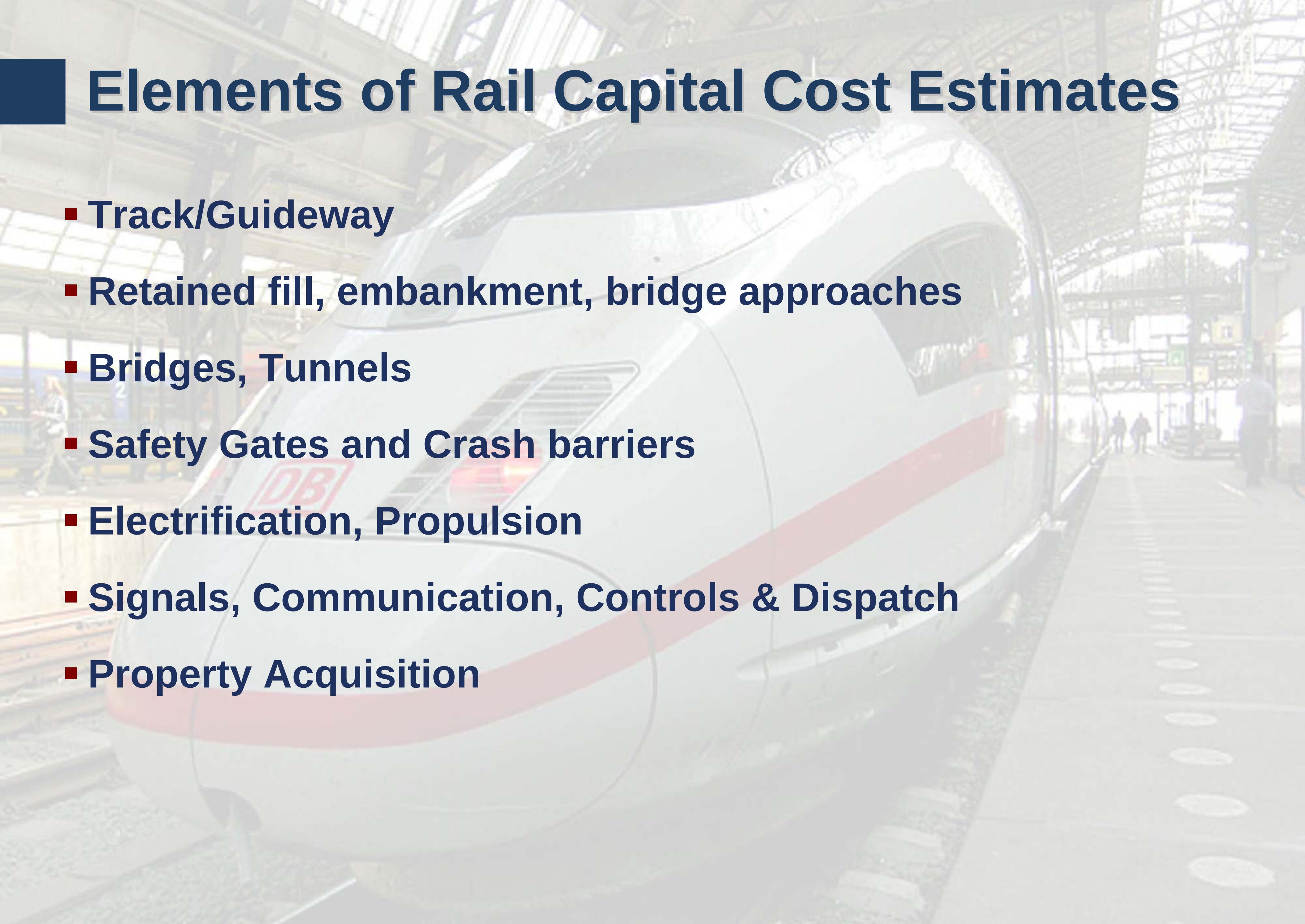
- **To share freight railroad property, FRA compliant equipment is needed.**
  - Only applies on existing rail routes on I-25 corridor, and beyond Minturn.
  - Otherwise elevated structure, very wide track spacing (which may not always be available) or completely separate rights of way (e.g. Greenfields) are needed to implement passenger rail.
- **Existing freight lines are at capacity, so we have to build all the new capacity that would be needed to provide passenger service.**
  - It has been assumed that existing capacity on some short sections, e.g. through the Littleton trench, might be made available if the R2C2 project were implemented.
  - In these areas, the freight RRs would have to acknowledge that they would not need the capacity that is freed up by R2C2 in the future.

Freight Rail Right of Way

- **Freight Rail Relocation has projected significant environmental benefit, such as fuel savings, and reduced emissions and exposure to highway grade crossing accidents.**
  - Freight Rail Relocation would provide significant rail cost-savings opportunity not only for passenger service south to Pueblo, but also to DIA and the northern front range cities.
  - Nonetheless, there is a risk associated with assuming relocation; legislation has been proposed to block it.
  - RMRA has requested that costs of avoiding Freight Rail Relocation be identified with any remaining options that assume it

Capital Costing Considerations

Elements of Rail Capital Cost Estimates



- Track/Guideway
- Retained fill, embankment, bridge approaches
- Bridges, Tunnels
- Safety Gates and Crash barriers
- Electrification, Propulsion
- Signals, Communication, Controls & Dispatch
- Property Acquisition

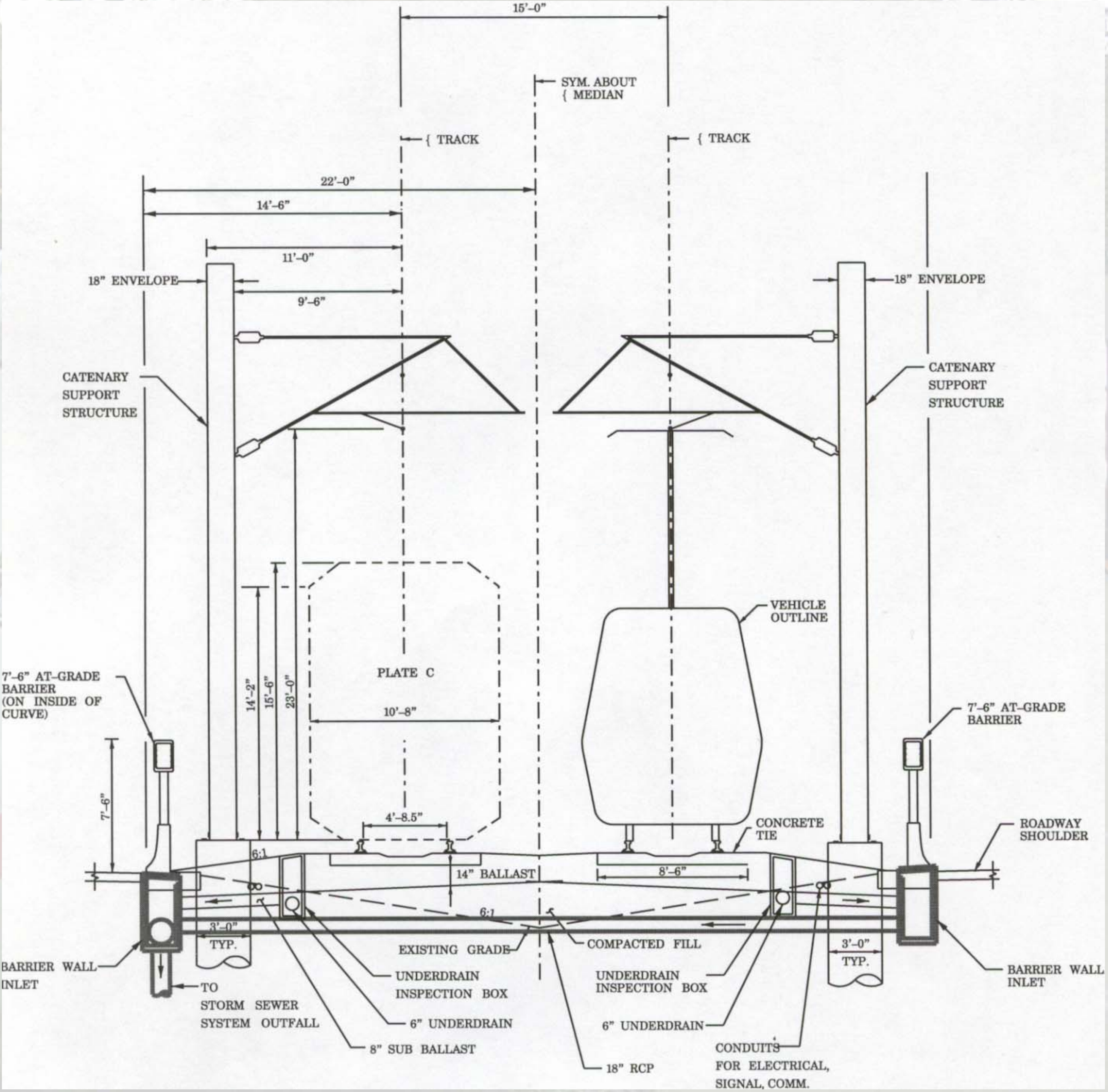
Example 1: At-Grade Rail Section

Double Track Electrified Rail Section

$3.1 M/mi

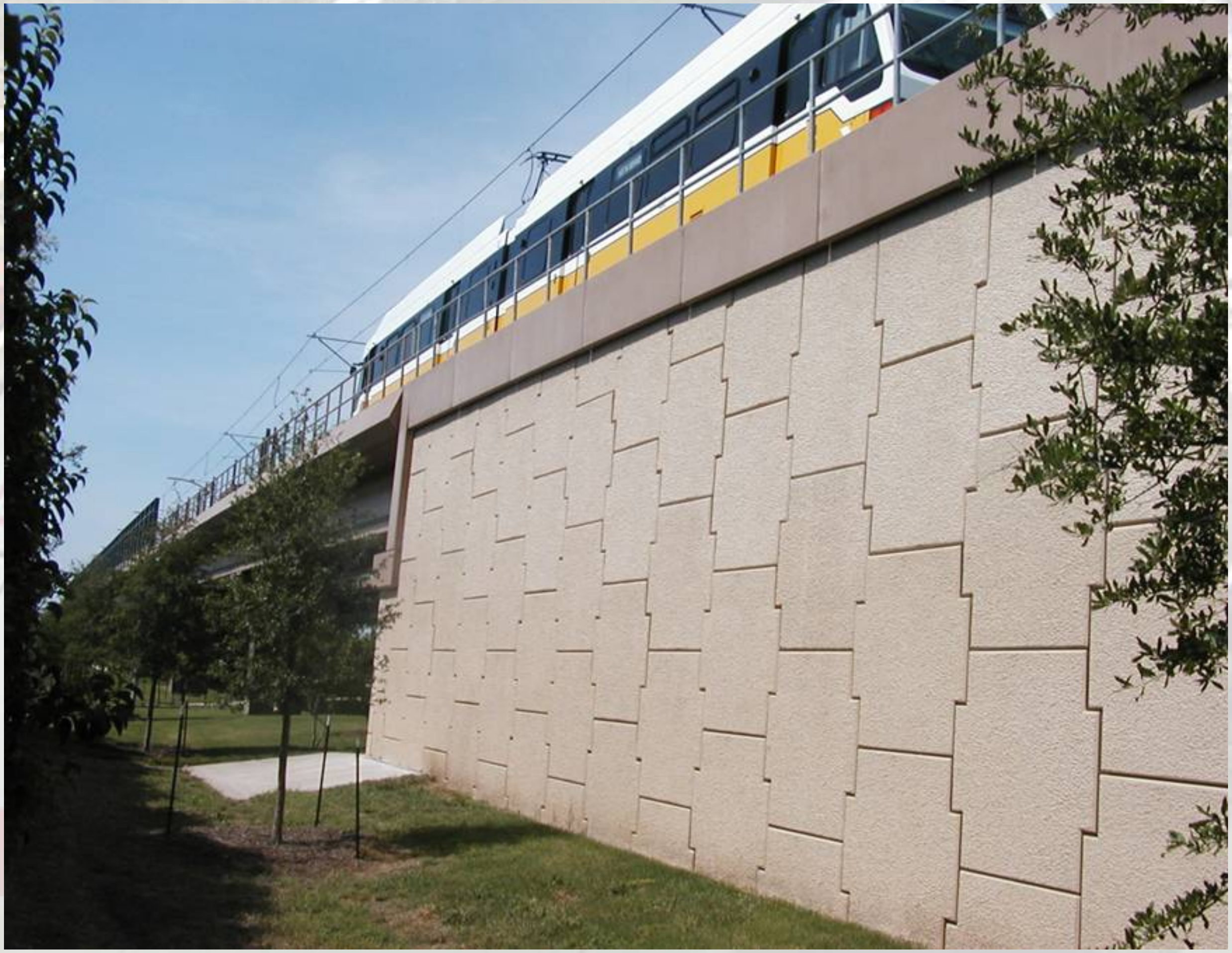
Signals, Communication & Dispatch

$1.5 M/mi



Source: ***Tampa to Miami Feasibility Study*****, Florida High Speed Rail Authority, March, 2003**

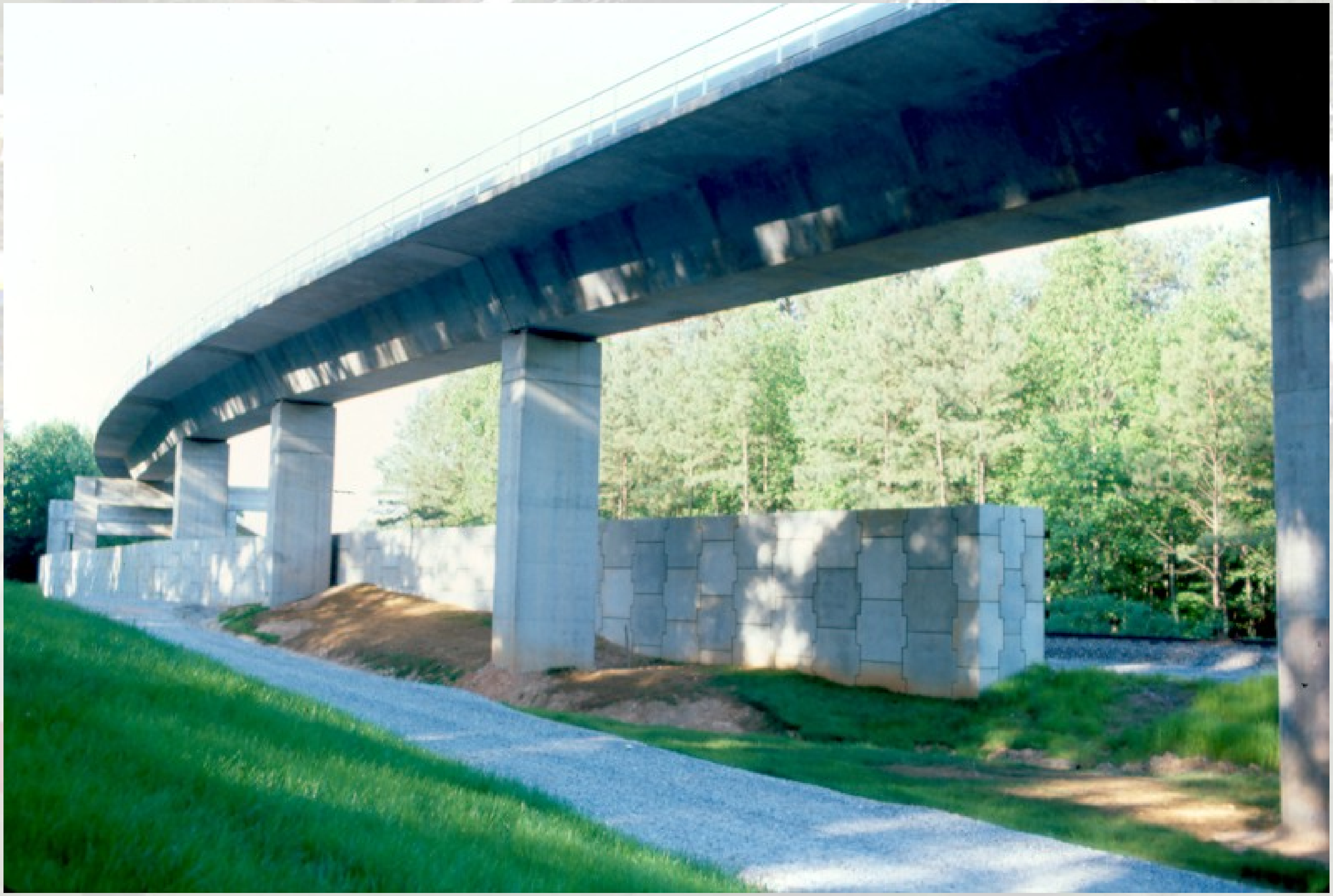
Example 2:
Double Track Retained Earth Fill



$16.7 M/mi

Source: Reinforced Earth Company

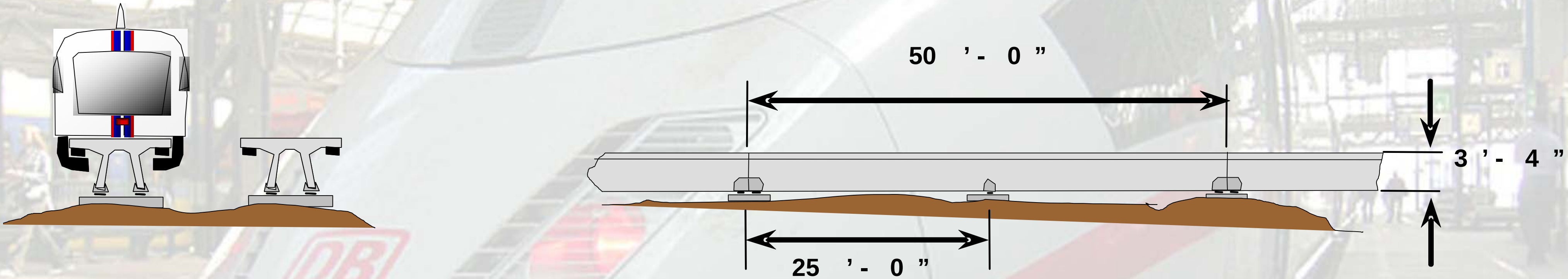
Example 3:
Rail Elevated Structure for Double Track



$42.2 M/mi

Source: Reinforced Earth Company

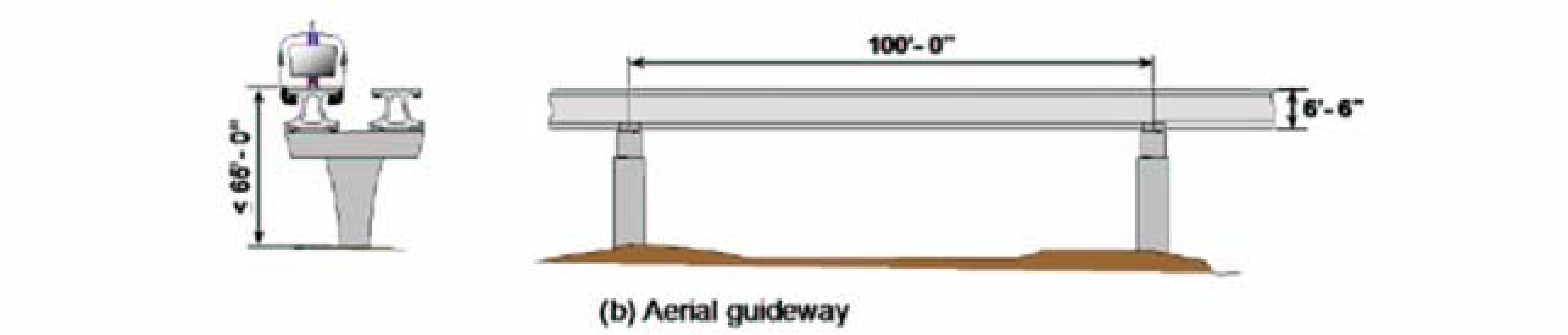
Example 4:
Maglev At Grade Guideway



$18.0 M/mi

Source: SANDAG Maglev Study Phase 1, Final Report

Example 5:
Maglev Aerial Guideway

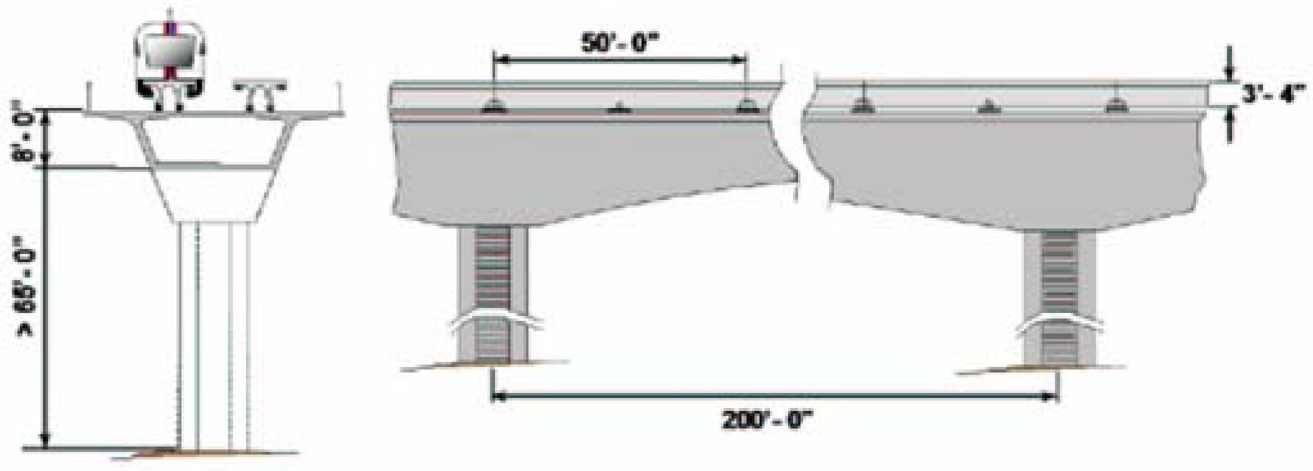


(b) Aerial guideway

$34.8 M/mi

Source: SANDAG Maglev Study Phase 1

Example 6:
Maglev Bridge Structure



(c) Bridge structure

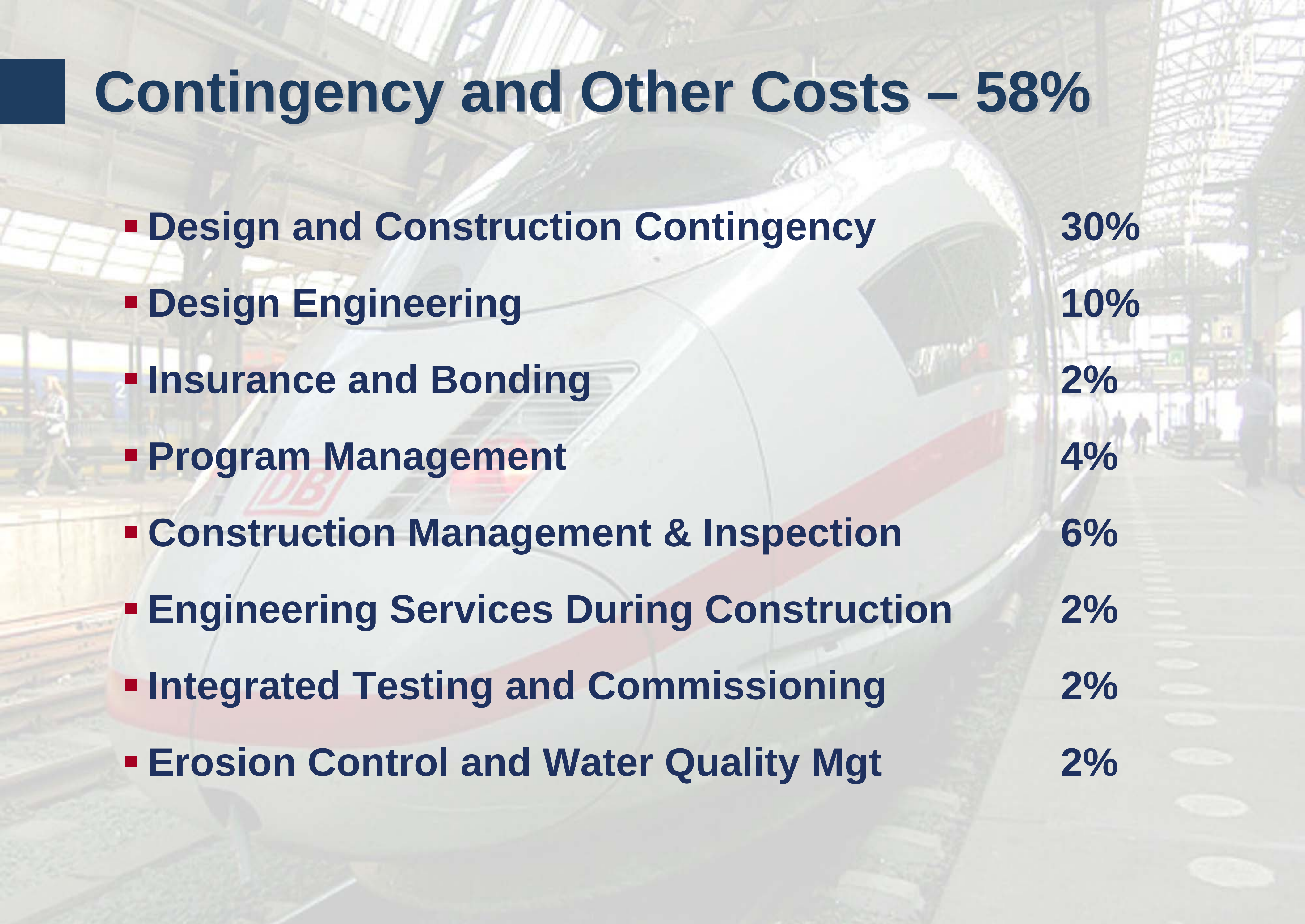
$136.2 M/mi

Source: SANDAG Maglev Study Phase 1

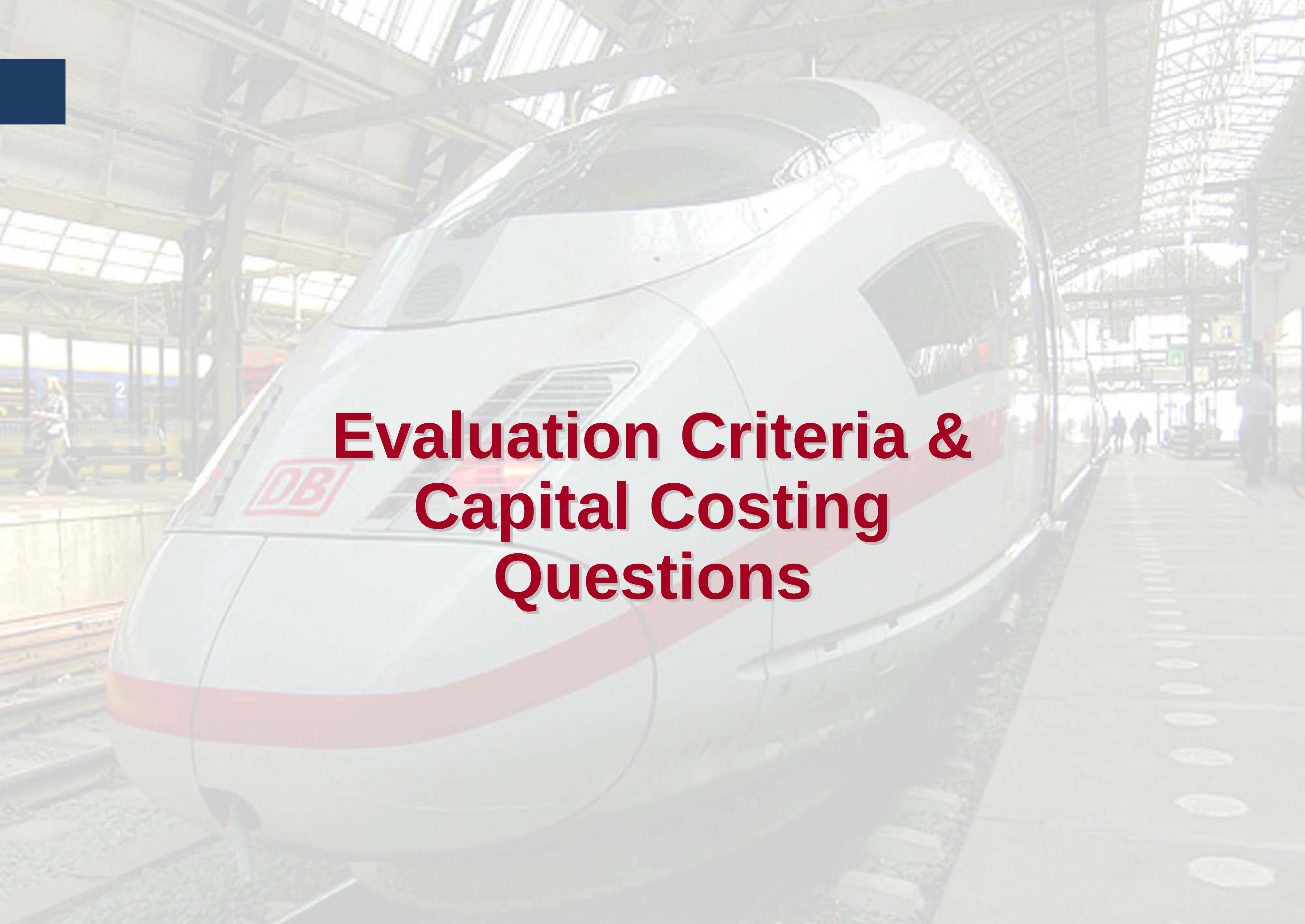
Land Acquisition Assumptions
(100’ Right-Of-Way)

- **Rural - $129,000 per mile**
  - Cost per acre – $10,000
- **Urban - $387,000 per mile**
  - Cost per acre – $30,000
- **Potential Issues**
  - ✓ Railroad Rights of Way
  - ✓ Property takes
- **CDOT informatino confirms costs used for land acquisition estimates**

Contingency and Other Costs – 58%



Design and Construction Contingency	30%
Design Engineering	10%
Insurance and Bonding	2%
Program Management	4%
Construction Management & Inspection	6%
Engineering Services During Construction	2%
Integrated Testing and Commissioning	2%
Erosion Control and Water Quality Mgt	2%

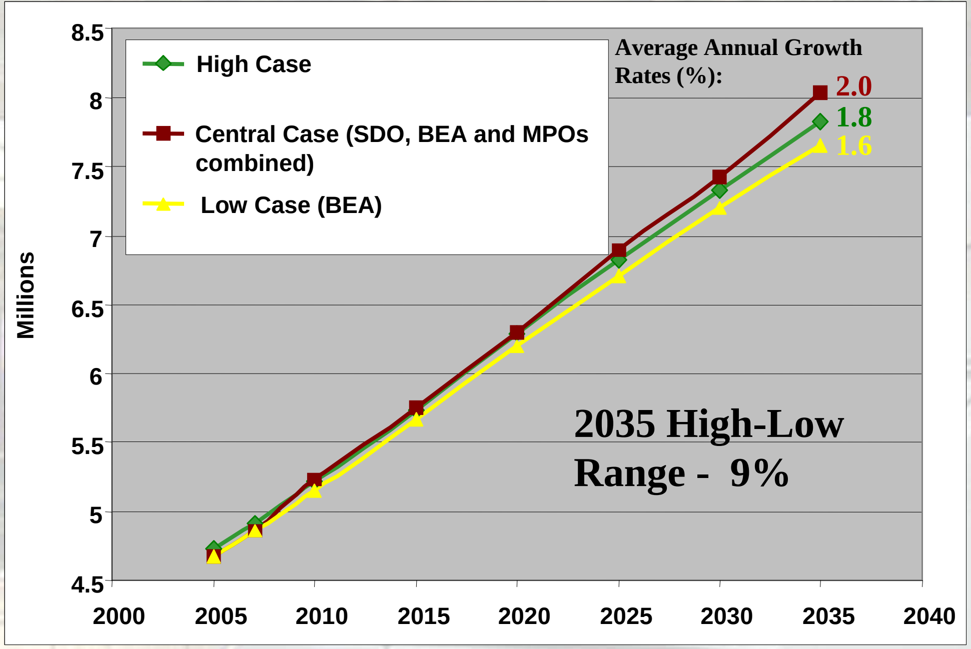


Evaluation Criteria & Capital Costing Questions

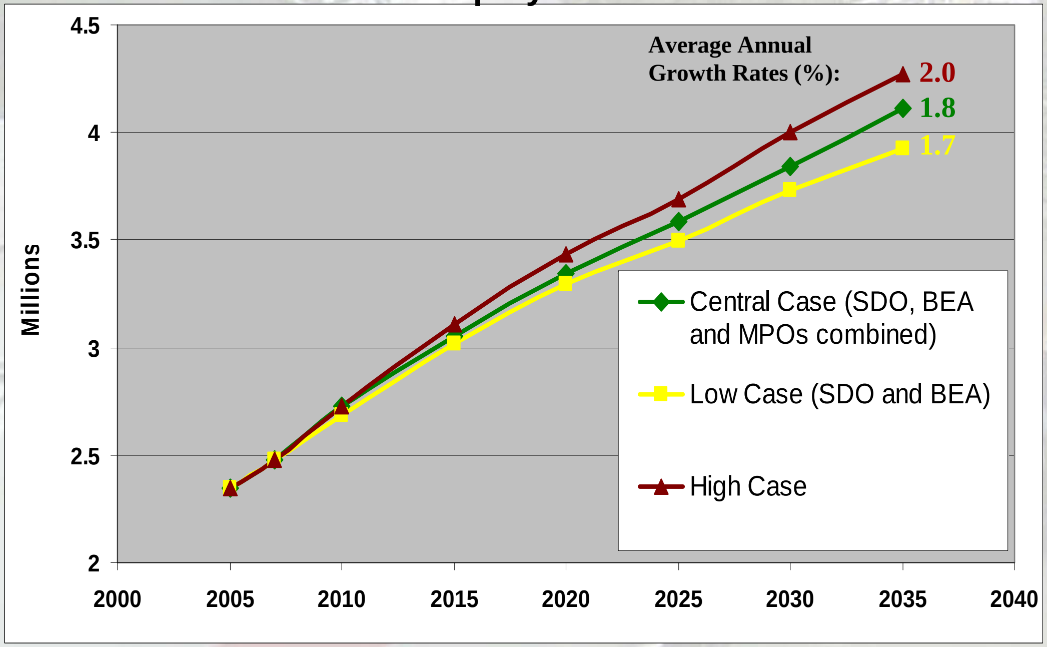
Ridership & Revenue Assumptions

Colorado Economic Scenarios

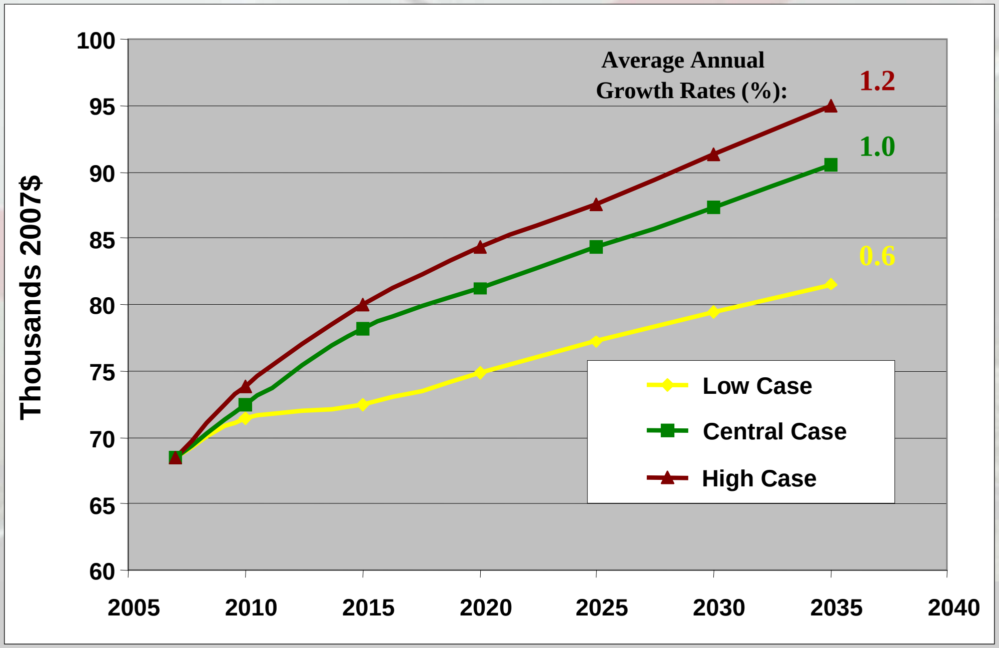
Population



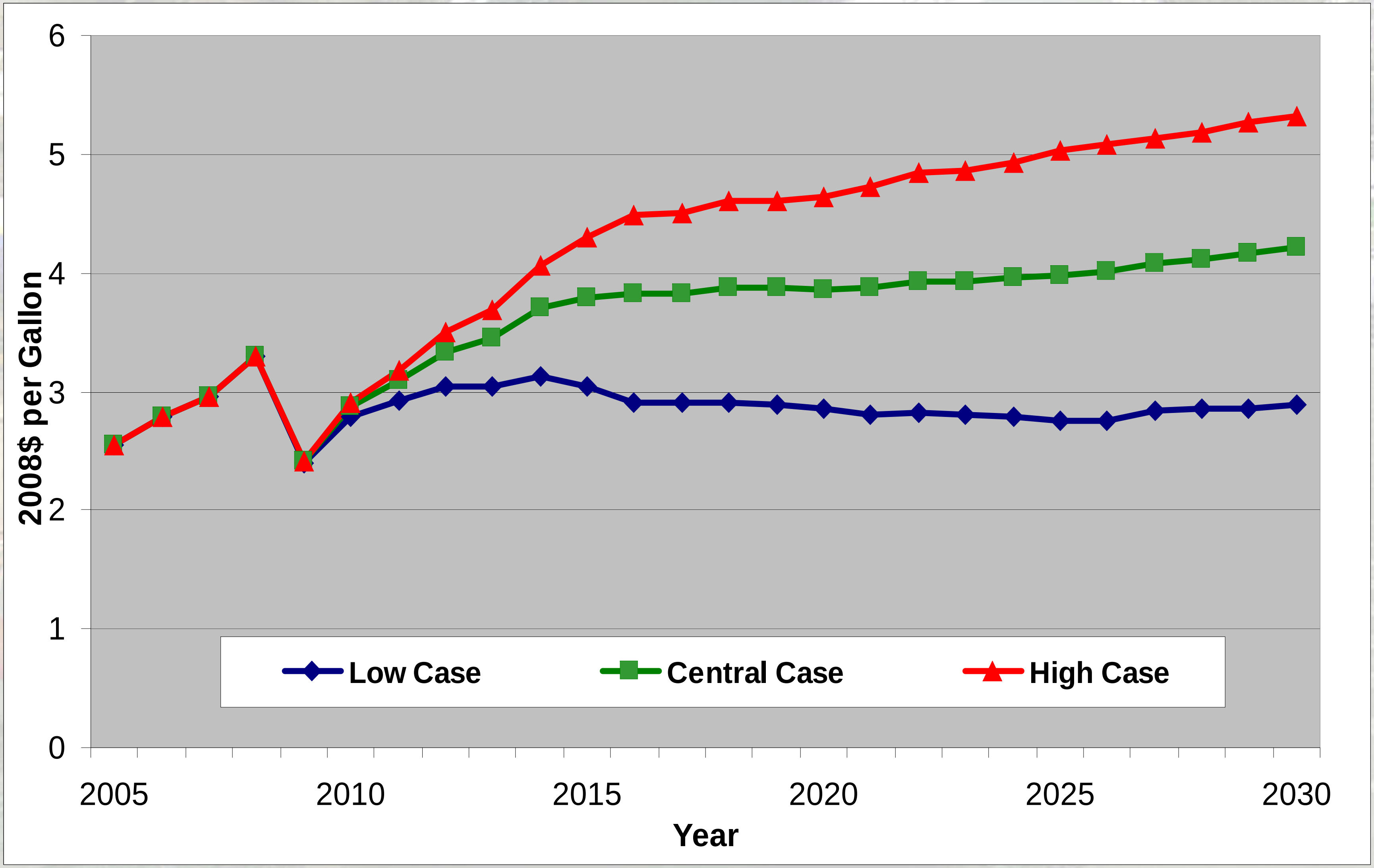
Employment



Income



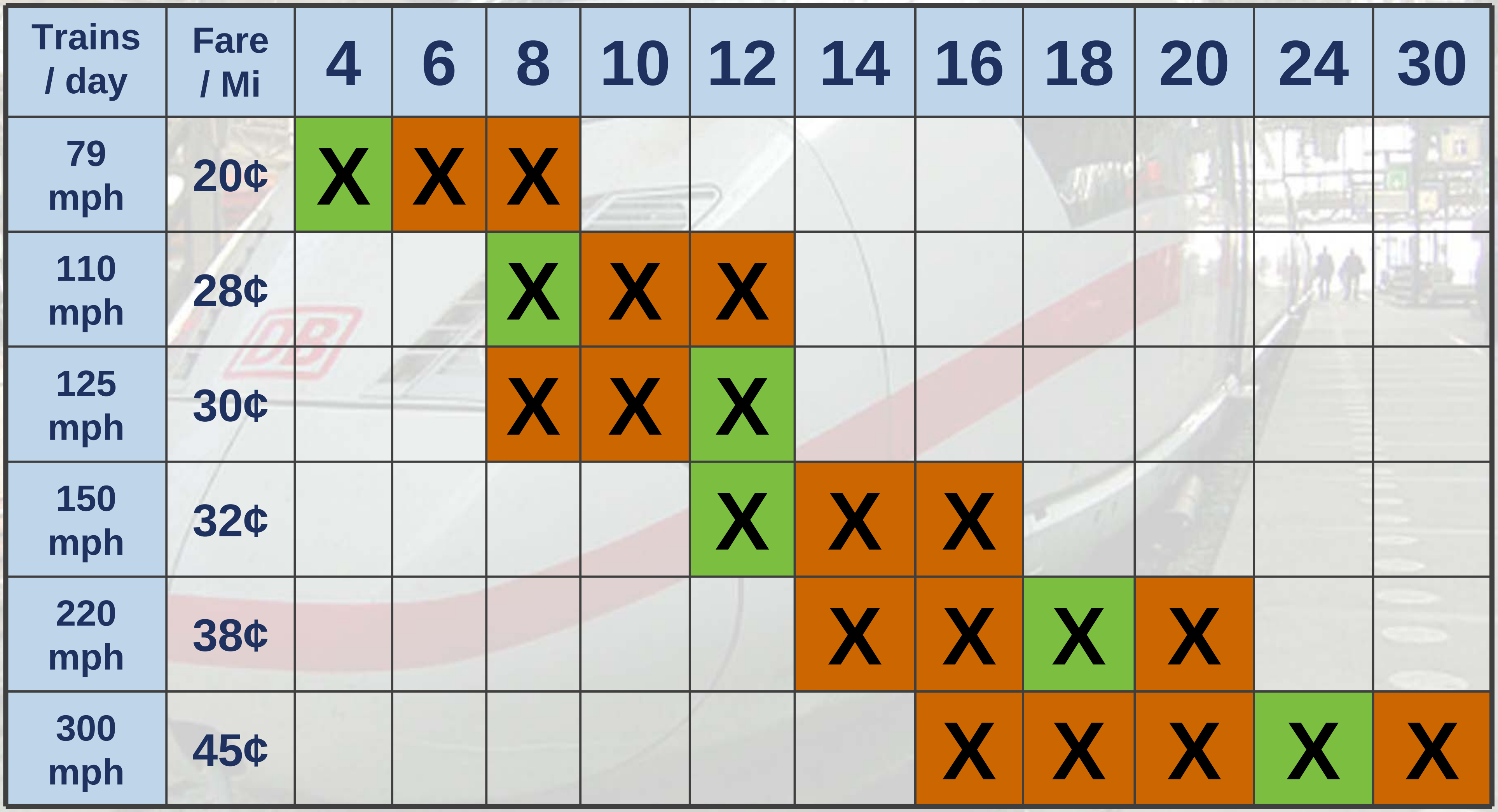
U.S. Retail Gasoline Prices - Historic Data and the Forecasts



Source: TEMS, Inc and Energy Information Administration.

Frequencies and Fares

Higher Speed technologies can typically support higher fares and frequencies. This optimizes the potential for each particular technology.



Trains / day	Fare / Mi	4	6	8	10	12	14	16	18	20	24	30
79 mph	20¢	X	X	X								
110 mph	28¢			X	X	X						
125 mph	30¢			X	X	X						
150 mph	32¢					X	X	X				
220 mph	38¢						X	X	X	X		
300 mph	45¢							X	X	X	X	X

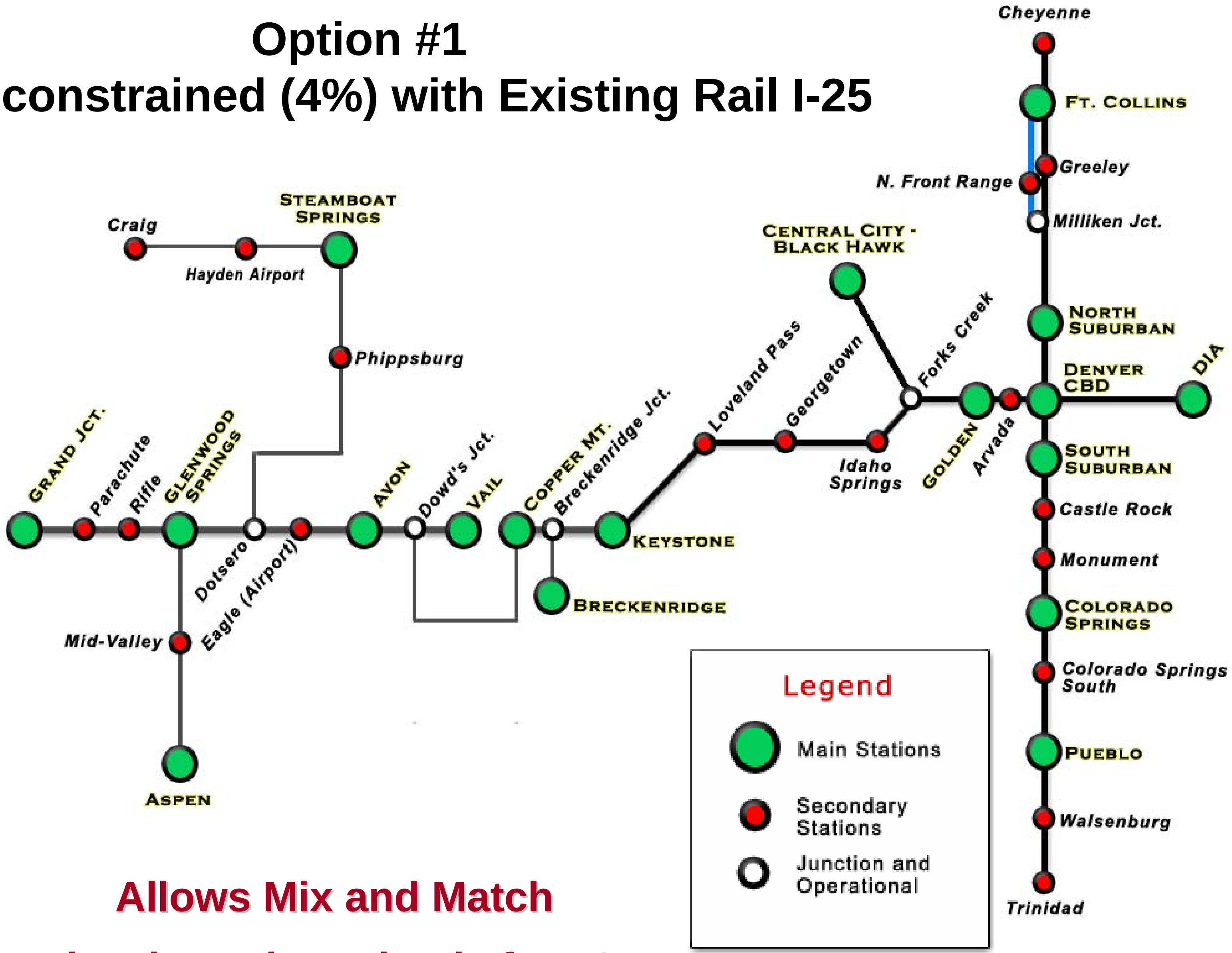
Two Network Options to be Evaluated

Option #1
I-70 Unconstrained (4%) with Existing Rail I-25

Conventional Amtrak

Talgo T21

Eurostar



Allows Mix and Match

Diesels evaluated only for I-25

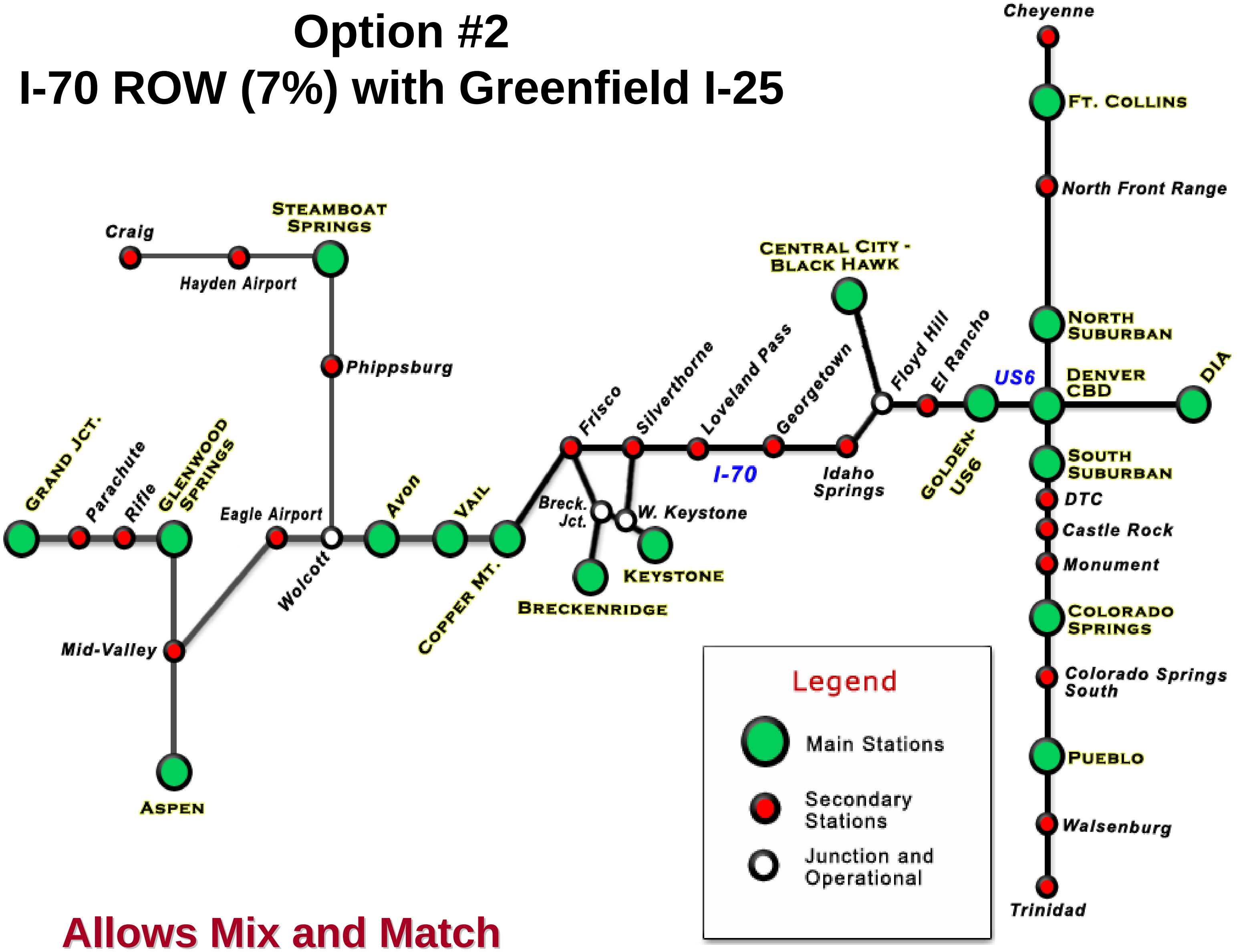
Two Network Options to be Evaluated

Option #2
I-70 ROW (7%) with Greenfield I-25

Proposed Colorado Maglev

ICE EMU

Transrapid Maglev



Allows Mix and Match

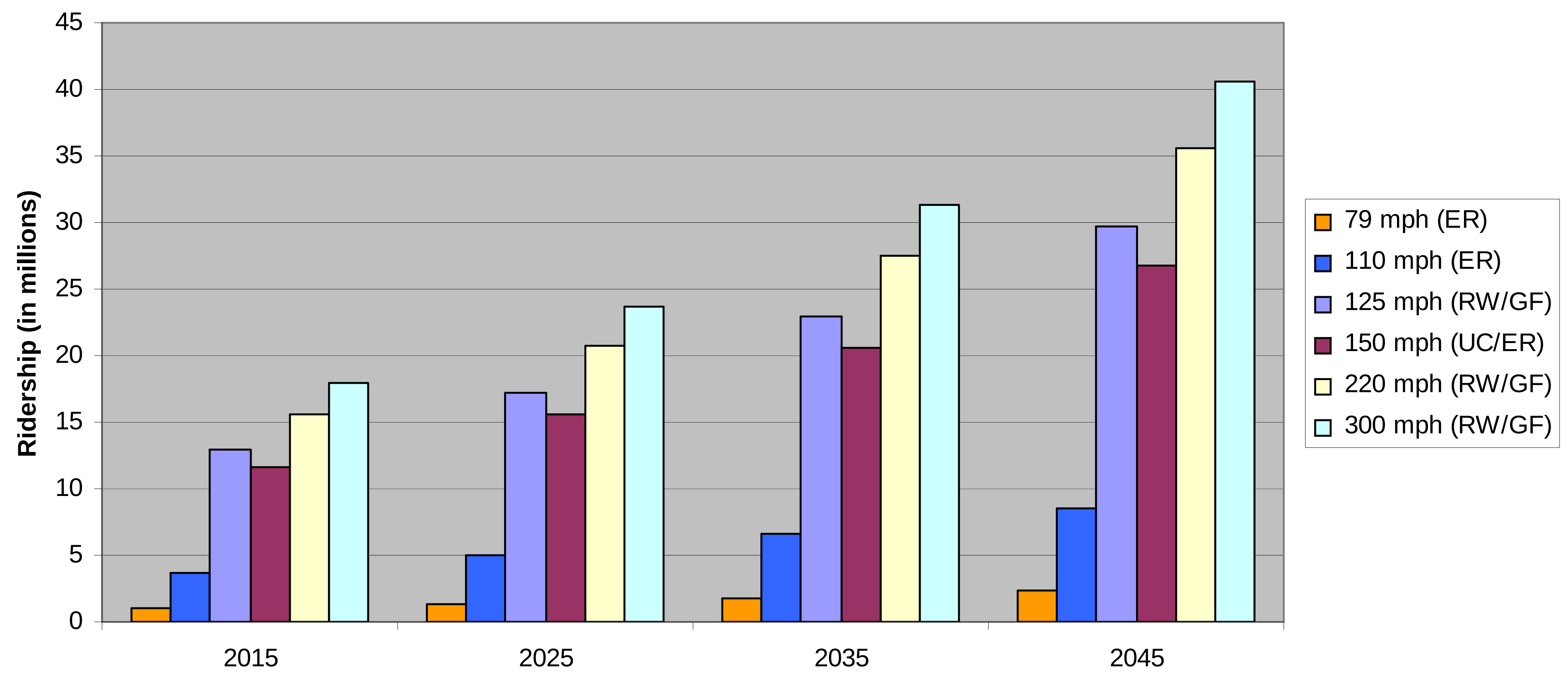
Ridership & Revenue

Central Demographics / Low Gas Case

Results and Sensitivities

Ridership by year (millions of riders)

(Central Demographic/Low Gas Case by Alternative Technology and Year)



Key

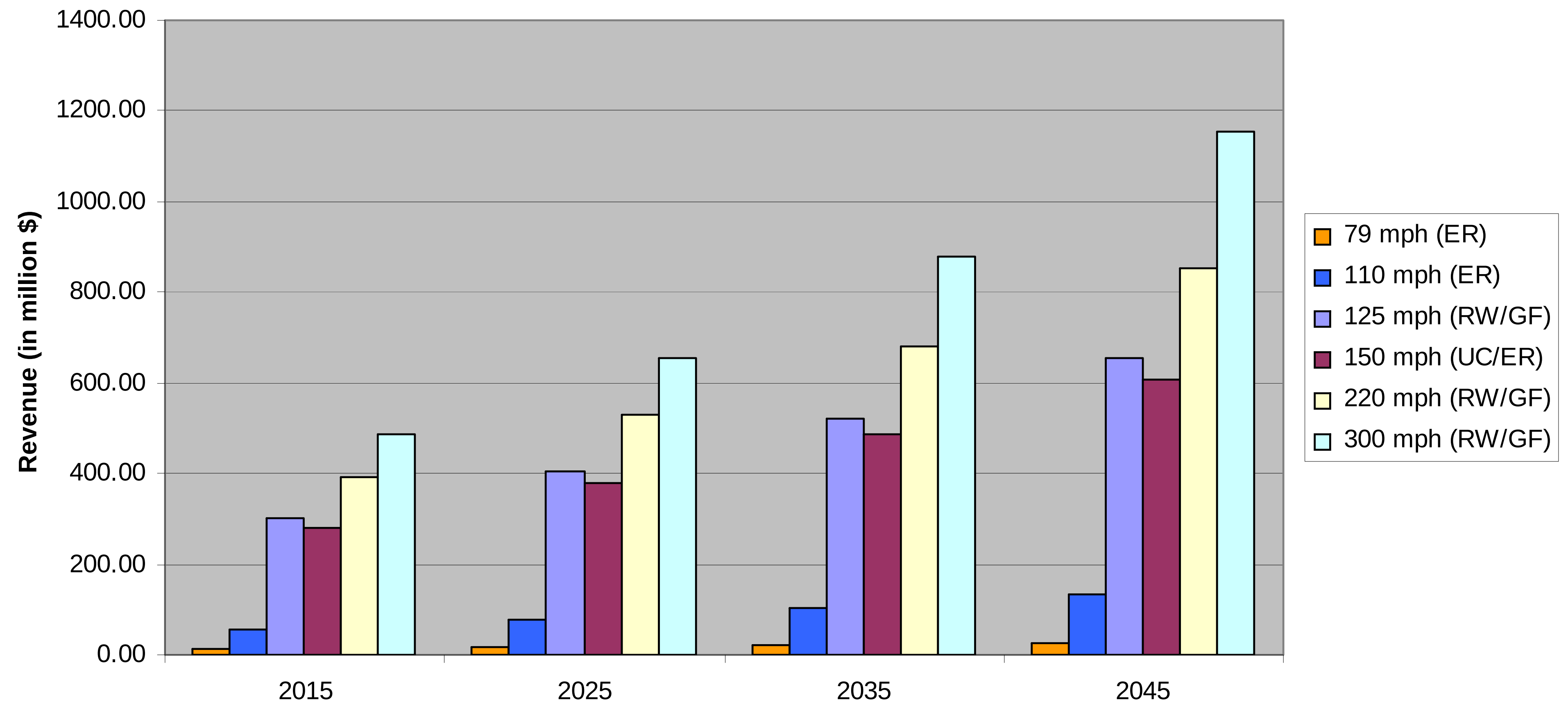
ER: I-25 Existing Rail
GF: I-25 Greenfield
RW: I-70 Right of Way 7%
UC: I-70 Unconstrained 4%

150-mph Ridership is lower because it uses the Existing Rail alignments on I-25 and west of Eagle;

Other High Speed technologies use Greenfield alignments, which, while more expensive, are faster and have better station locations

Revenue by year ($ millions)

(Central Demographic/Low Gas Case by Alternative Technology and Year)



Key

ER: I-25 Existing Rail
GF: I-25 Greenfield
RW: I-70 Right of Way 7%
UC: I-70 Unconstrained 4%

Note disproportionate increase in Revenue compared to Ridership of Higher Speed technologies, because of the ability to support higher fares.

Ridership: Millions of Riders –

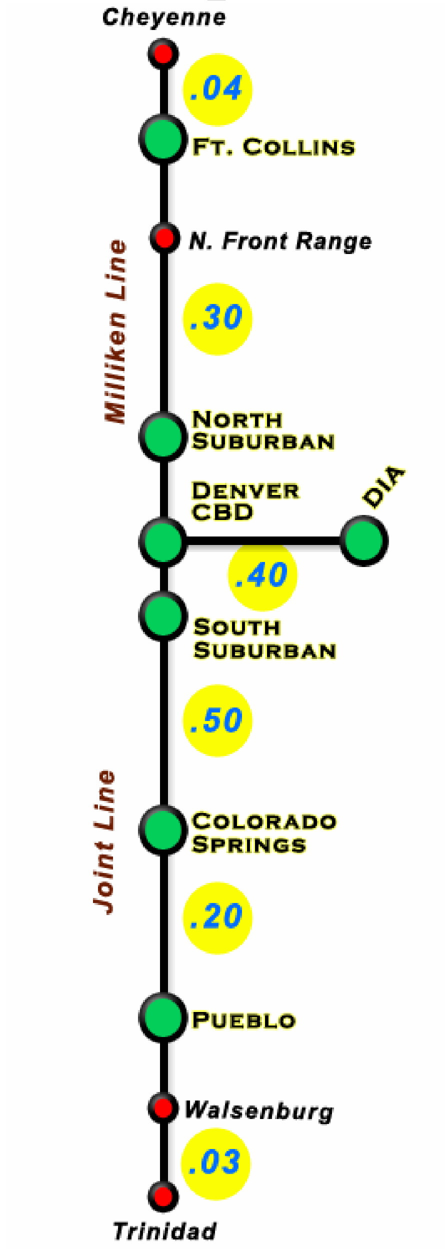
(Central Demographic/ Low Gas, 2025)

79-mph:
1.37 Million per year

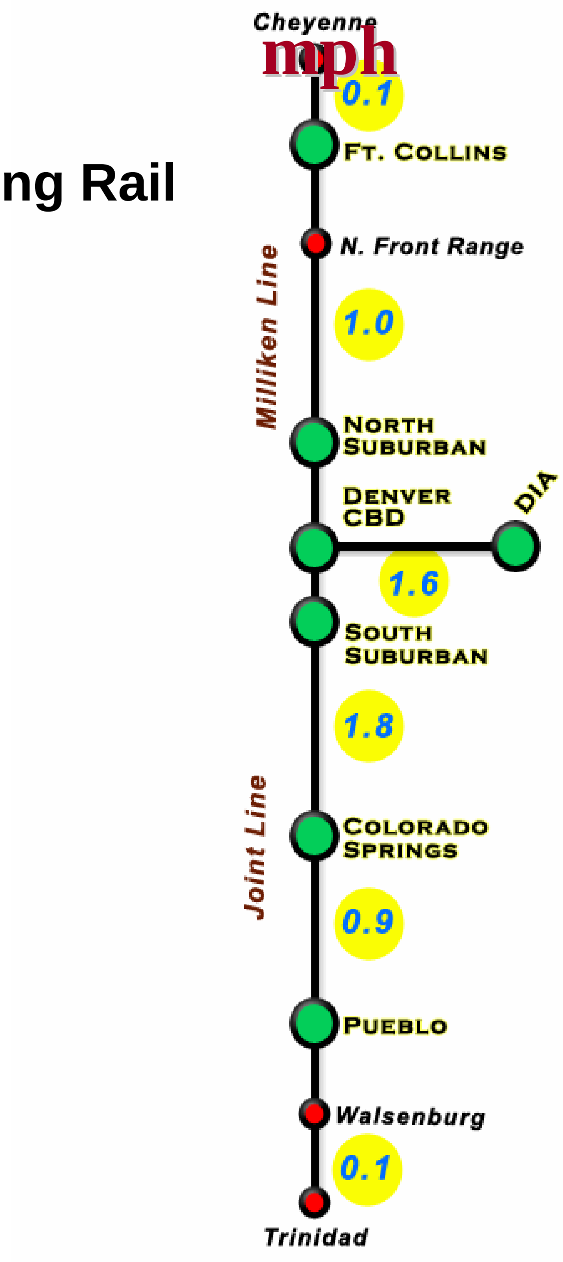
110-mph:
4.95 Million per year

I-25 – Existing Rail

79 mph



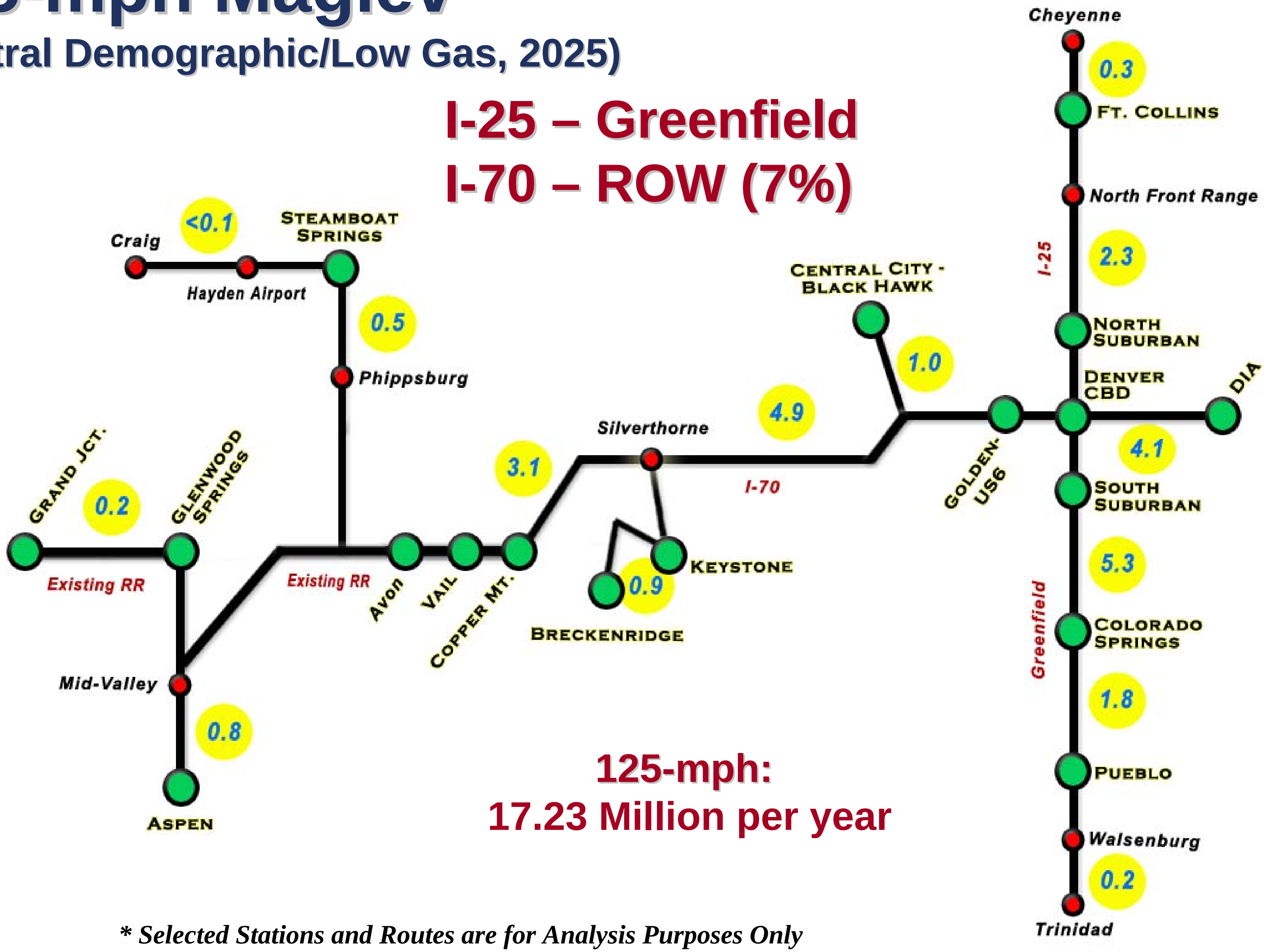
110 mph



** Selected Stations and Routes are for Analysis Purposes Only*

Ridership: Millions of Riders
125-mph Maglev
(Central Demographic/Low Gas, 2025)

I-25 – Greenfield
I-70 – ROW (7%)



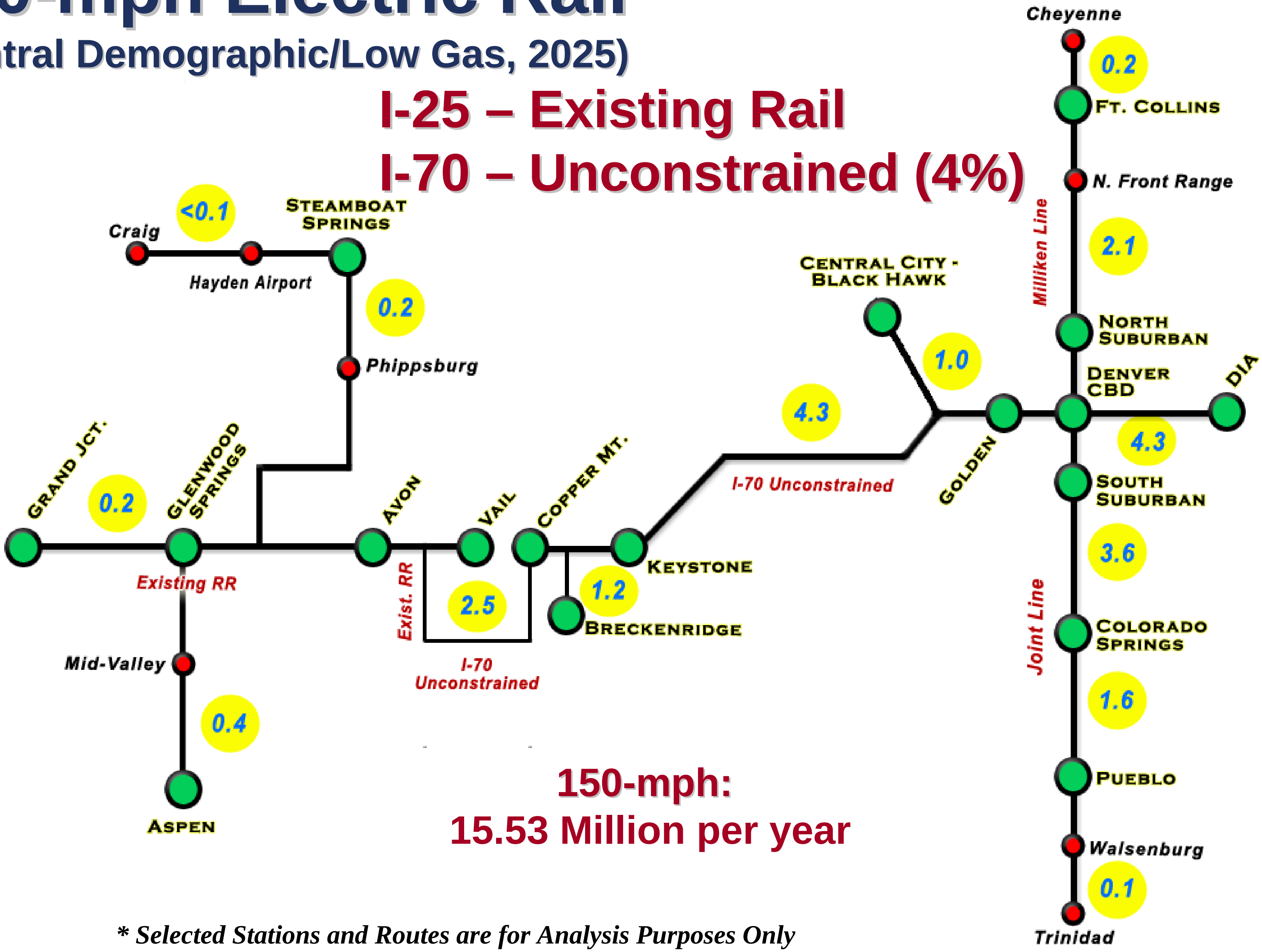
125-mph:
17.23 Million per year

** Selected Stations and Routes are for Analysis Purposes Only*

Ridership: Millions of Riders
150-mph Electric Rail

(Central Demographic/Low Gas, 2025)

I-25 – Existing Rail
I-70 – Unconstrained (4%)



150-mph:
15.53 Million per year

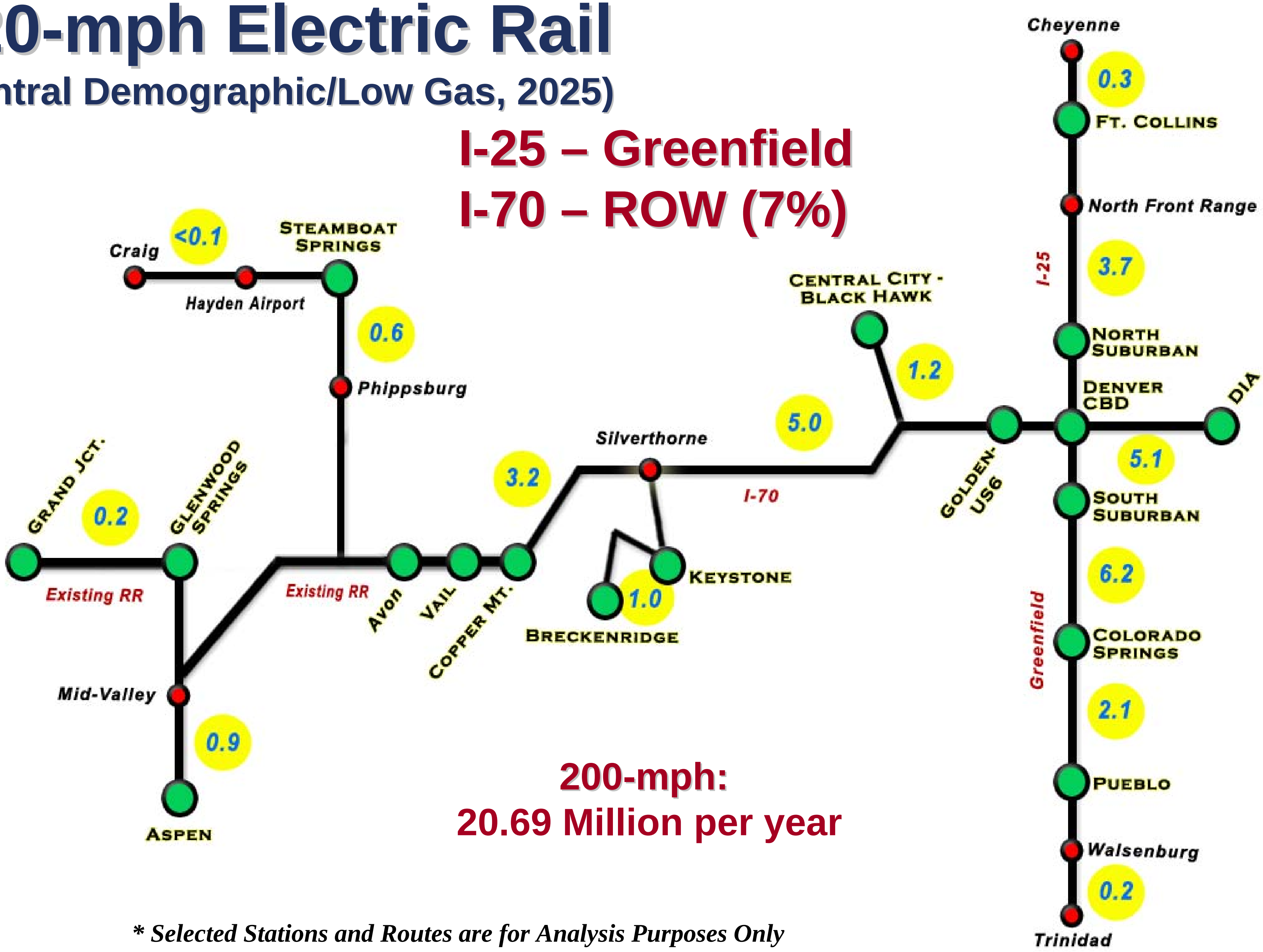
** Selected Stations and Routes are for Analysis Purposes Only*

Ridership: Millions of Riders
220-mph Electric Rail

(Central Demographic/Low Gas, 2025)

I-25 – Greenfield

I-70 – ROW (7%)



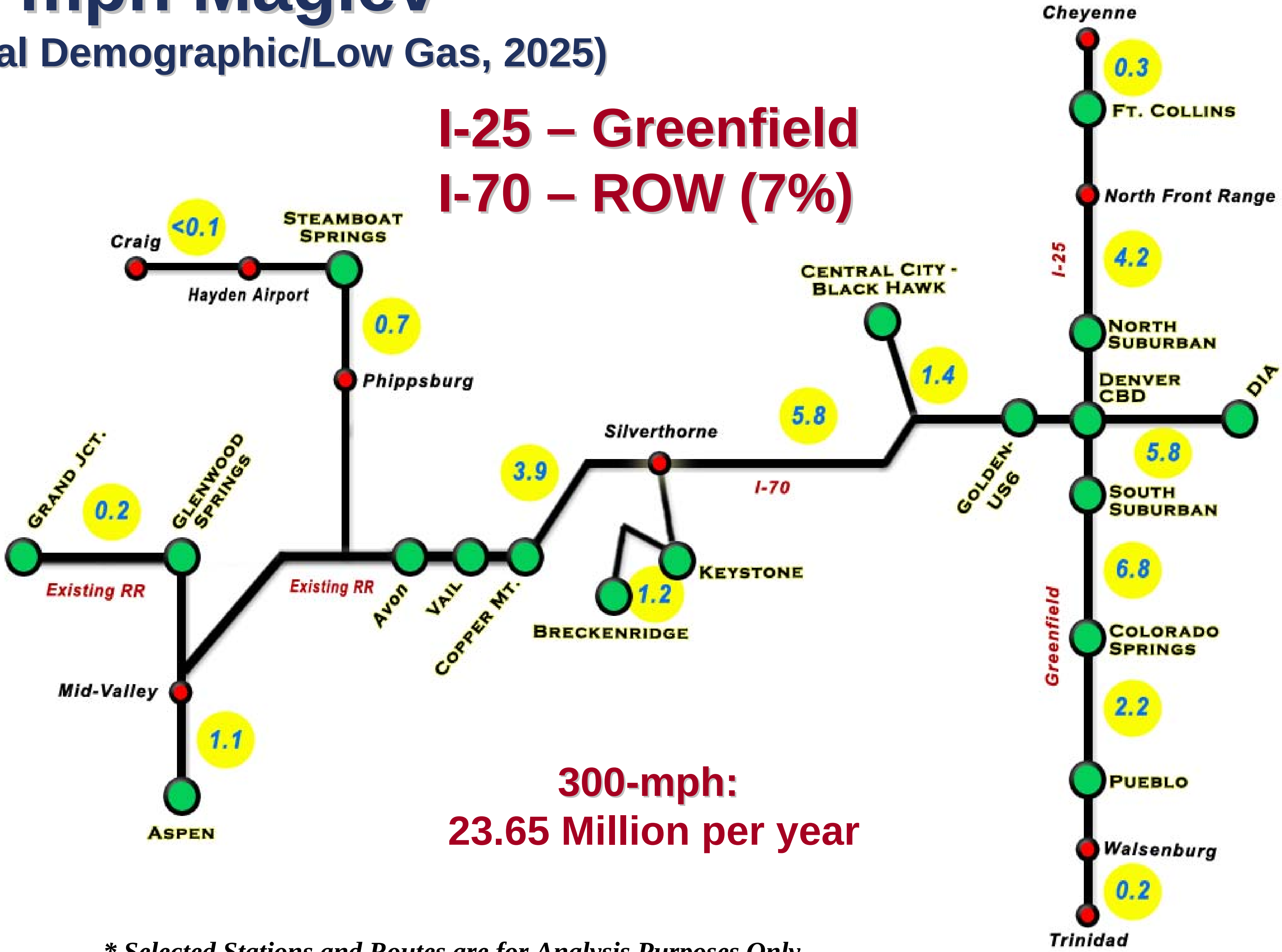
200-mph:
20.69 Million per year

** Selected Stations and Routes are for Analysis Purposes Only*

Ridership: Millions of Riders 300-mph Maglev

(Central Demographic/Low Gas, 2025)

I-25 – Greenfield
I-70 – ROW (7%)

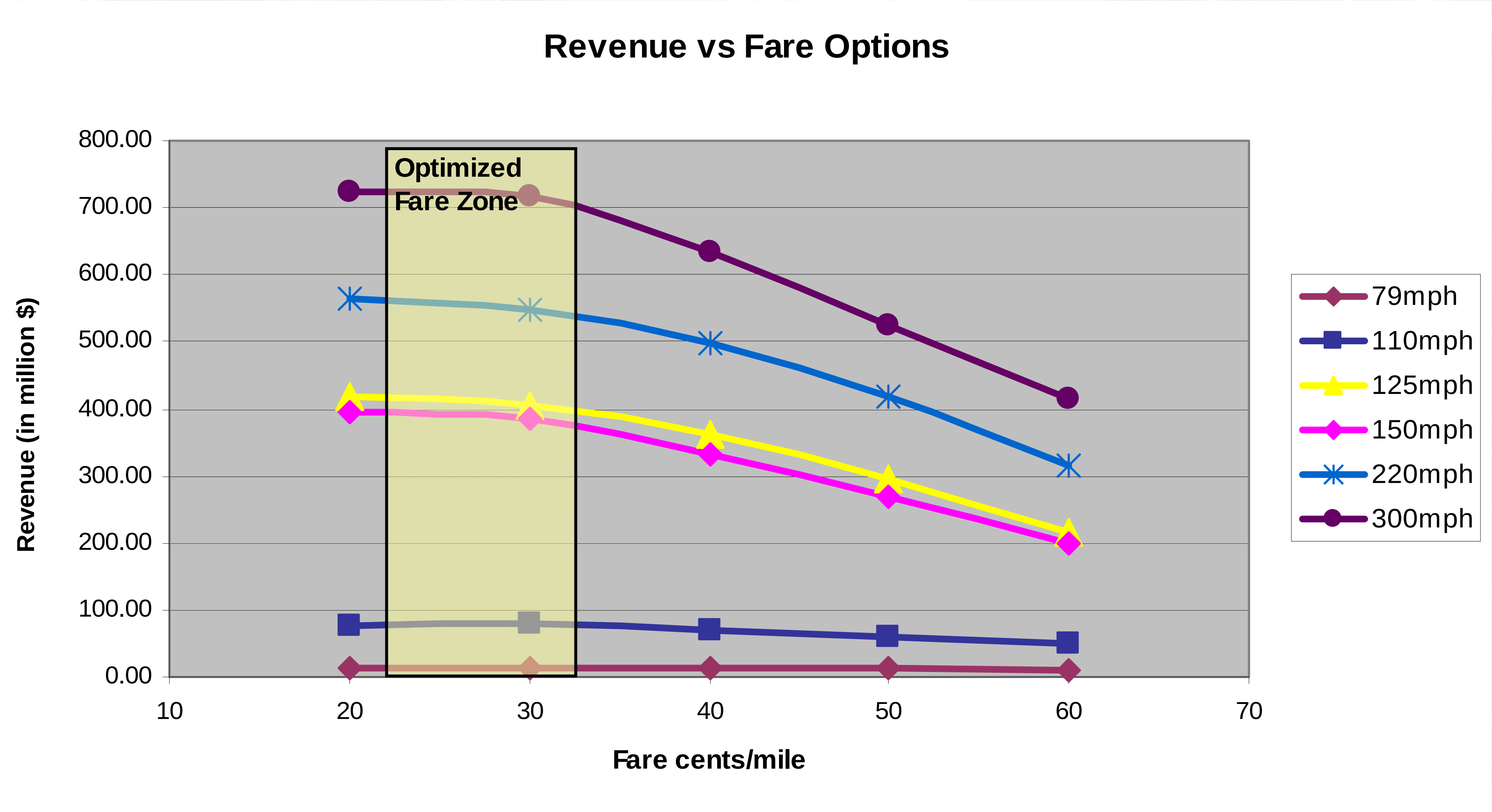


300-mph:
23.65 Million per year

** Selected Stations and Routes are for Analysis Purposes Only*

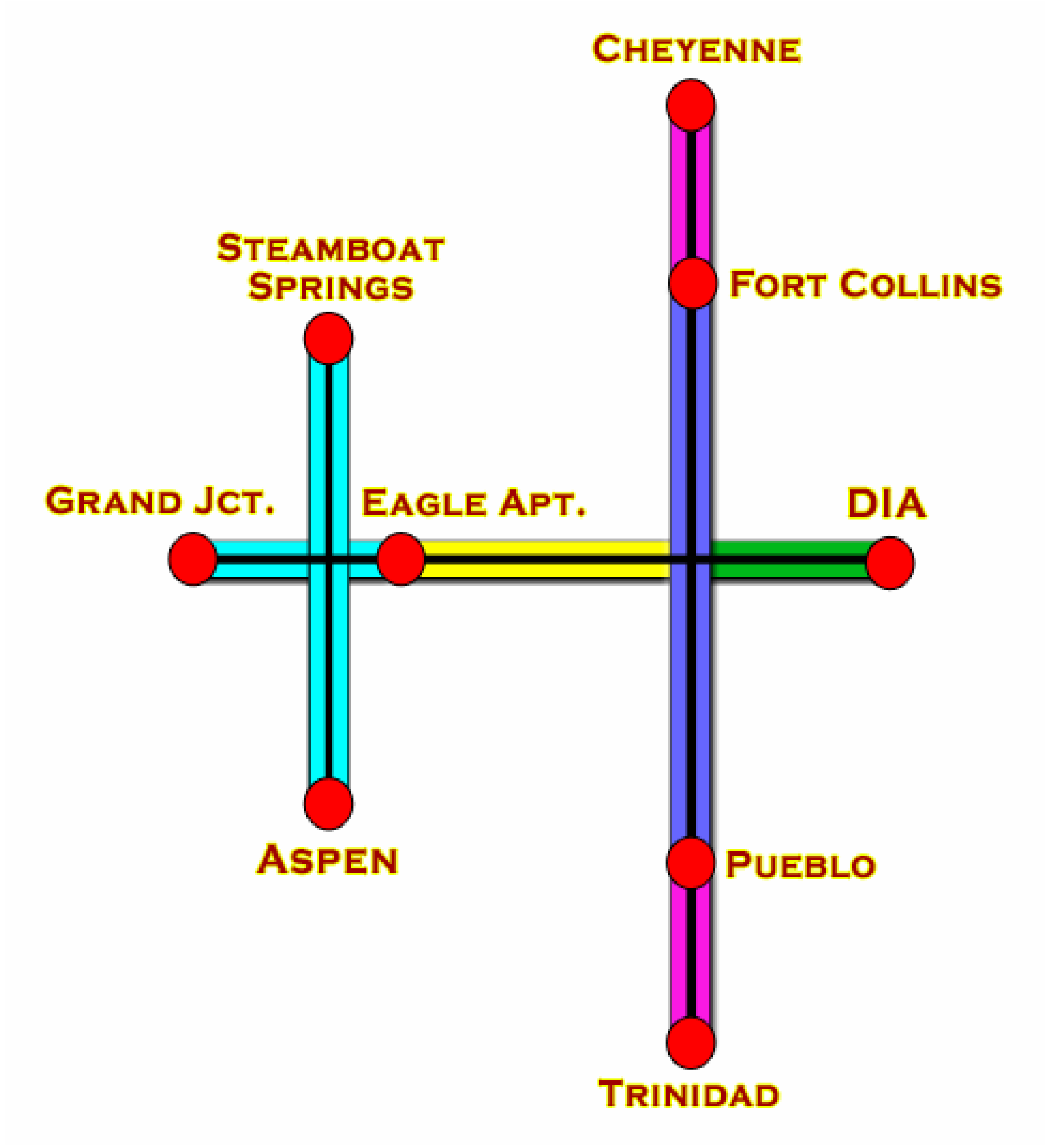
Fare Sensitivity: Impact of Fare Options on Alternative Technologies

(Central Demographic/Low Gas Case, 2025)



Capital Costs

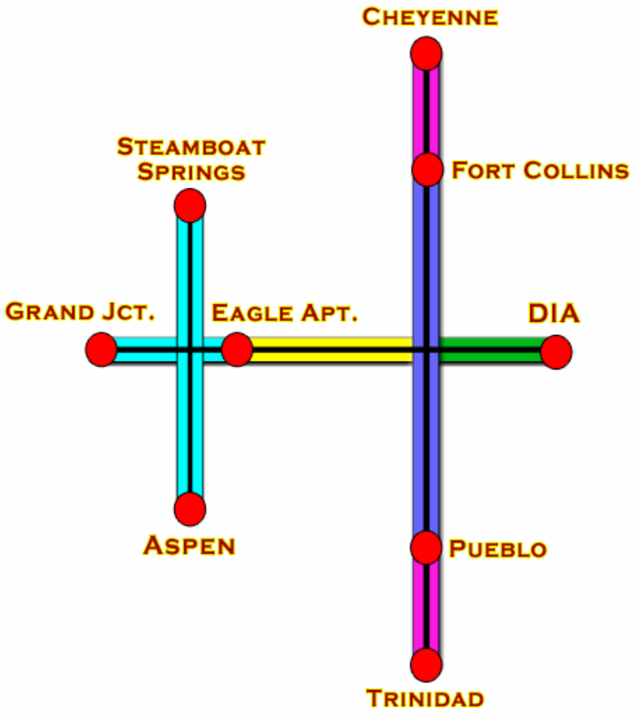
Major Capital Cost Segments



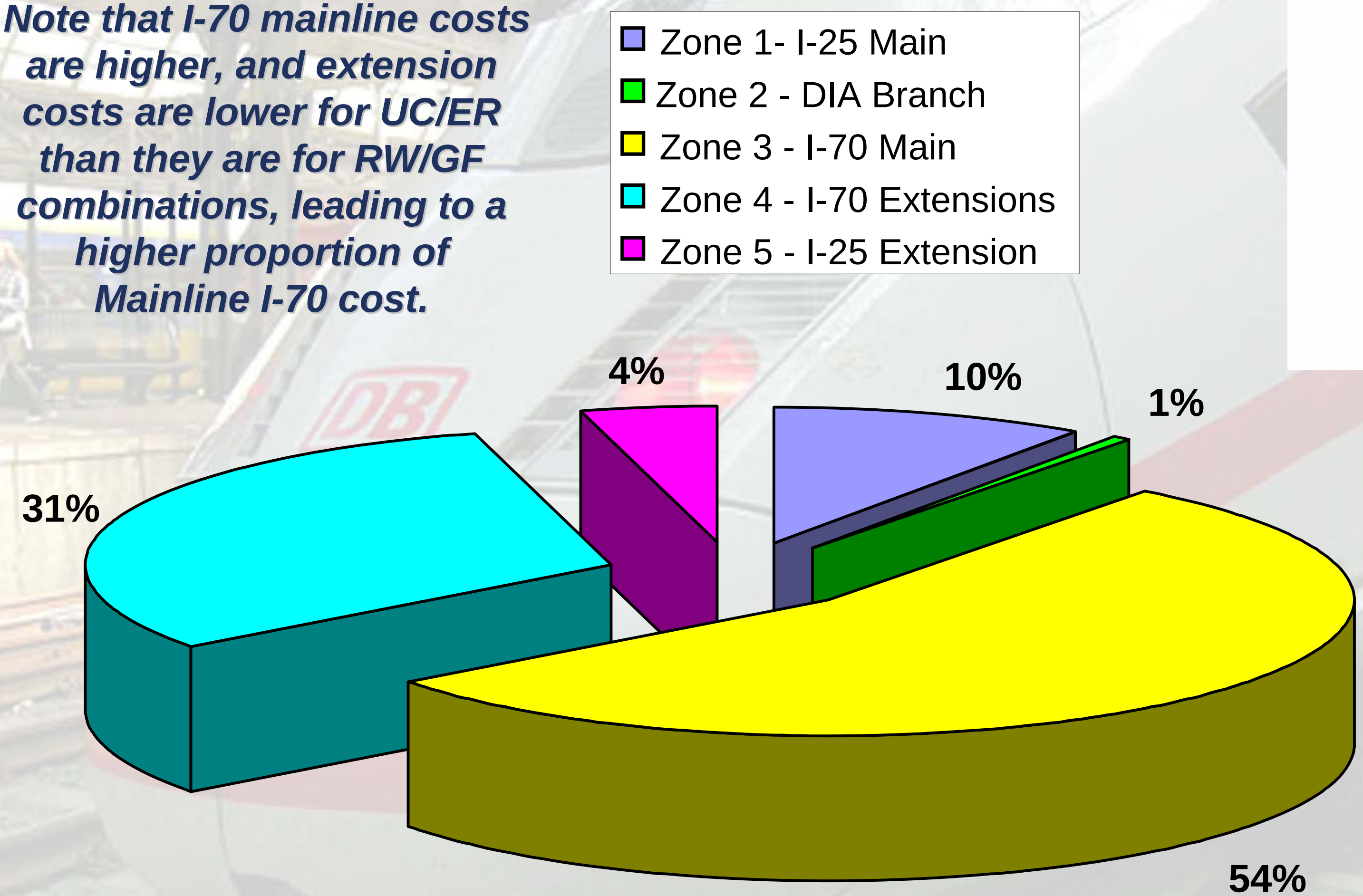
LEGEND

- 🟦 Zone 1 – I-25 Main
- 🟩 Zone 2 – DIA Branch
- 🟨 Zone 3 – I-70 Main
- 🟦 Zone 4 – I-70 Extensions
- 🟪 Zone 5 – I-25 Extensions

150-mph UC/ER Rail Capital Cost by Major Segments



Note that I-70 mainline costs are higher, and extension costs are lower for UC/ER than they are for RW/GF combinations, leading to a higher proportion of Mainline I-70 cost.

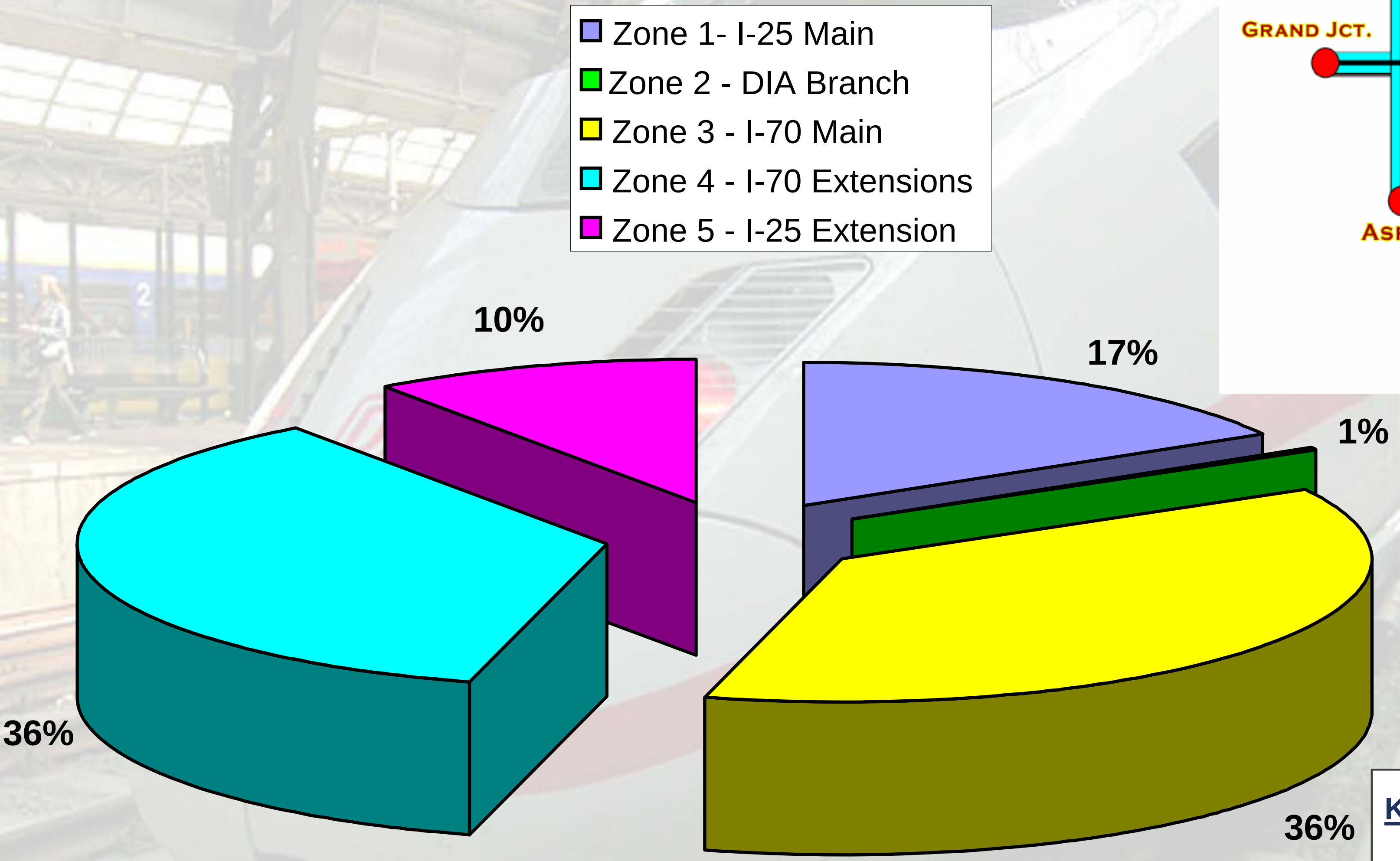


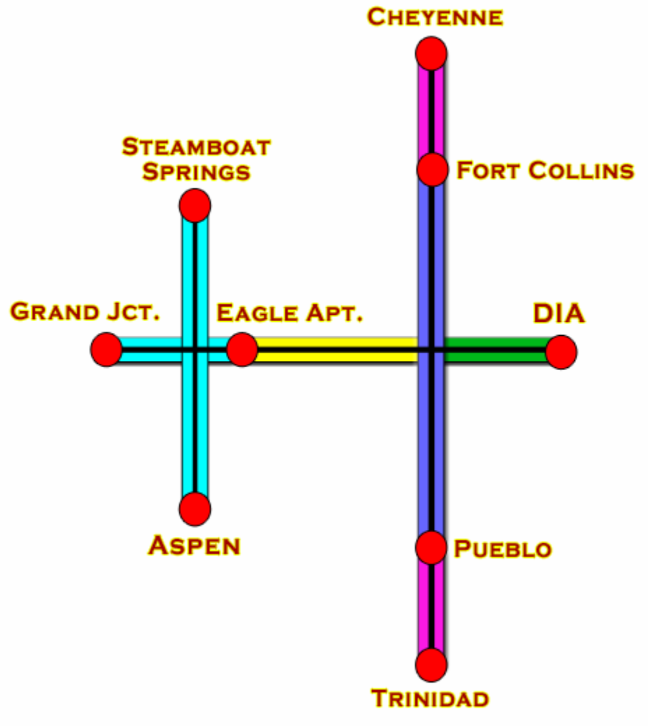
65%of Capital generates 93% of Revenue

Key

ER: I-25 Existing Rail
GF: I-25 Greenfield
RW: I-70 Right of Way 7%
UC: I-70 Unconstrained 4%

220-mph RW/GF Rail Capital Cost by Major Segments



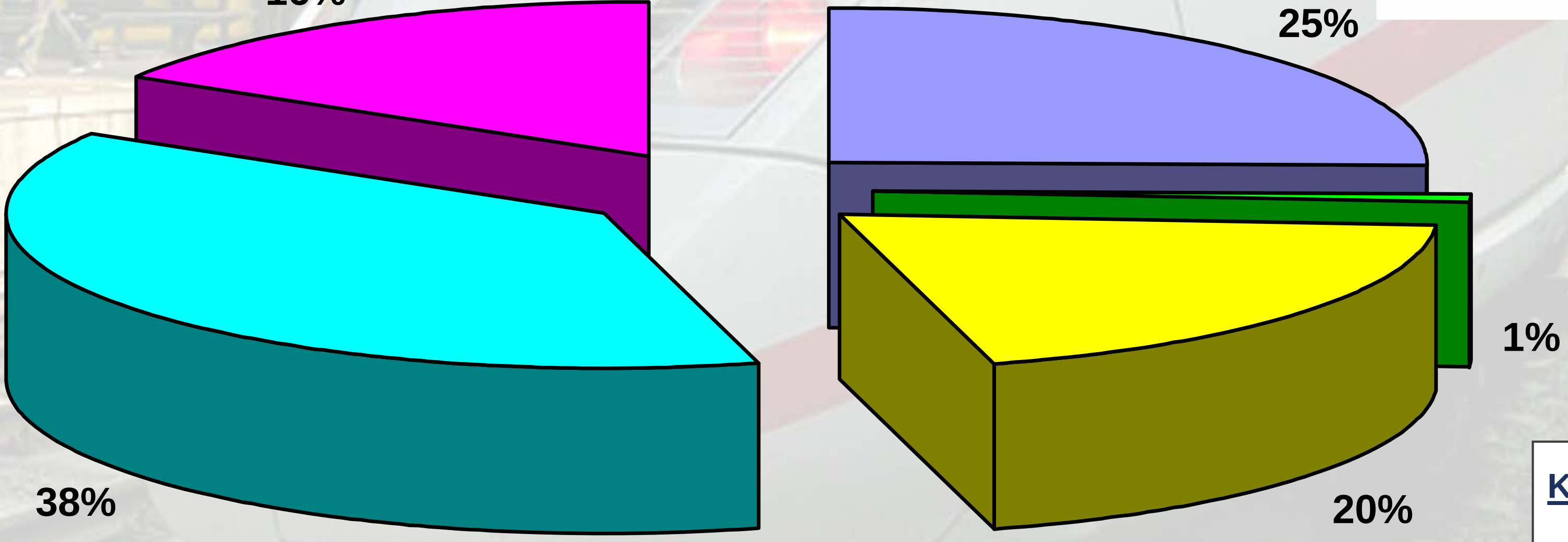


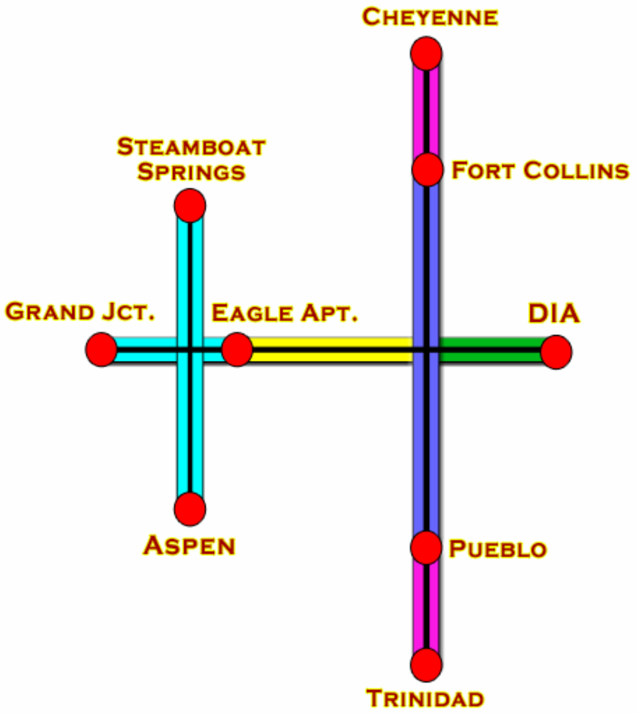
Key

ER: I-25 Existing Rail
GF: I-25 Greenfield
RW: I-70 Right of Way 7%
UC: I-70 Unconstrained 4%

54% of Capital generates 95% of Revenue

300-mph RW/GF Maglev Capital Cost by Major Segments


- 🟦 Zone 1- I-25 Main
- 🟩 Zone 2 - DIA Branch
- 🟨 Zone 3 - I-70 Main
- 🟦 Zone 4 - I-70 Extensions
- 🟪 Zone 5 - I-25 Extension

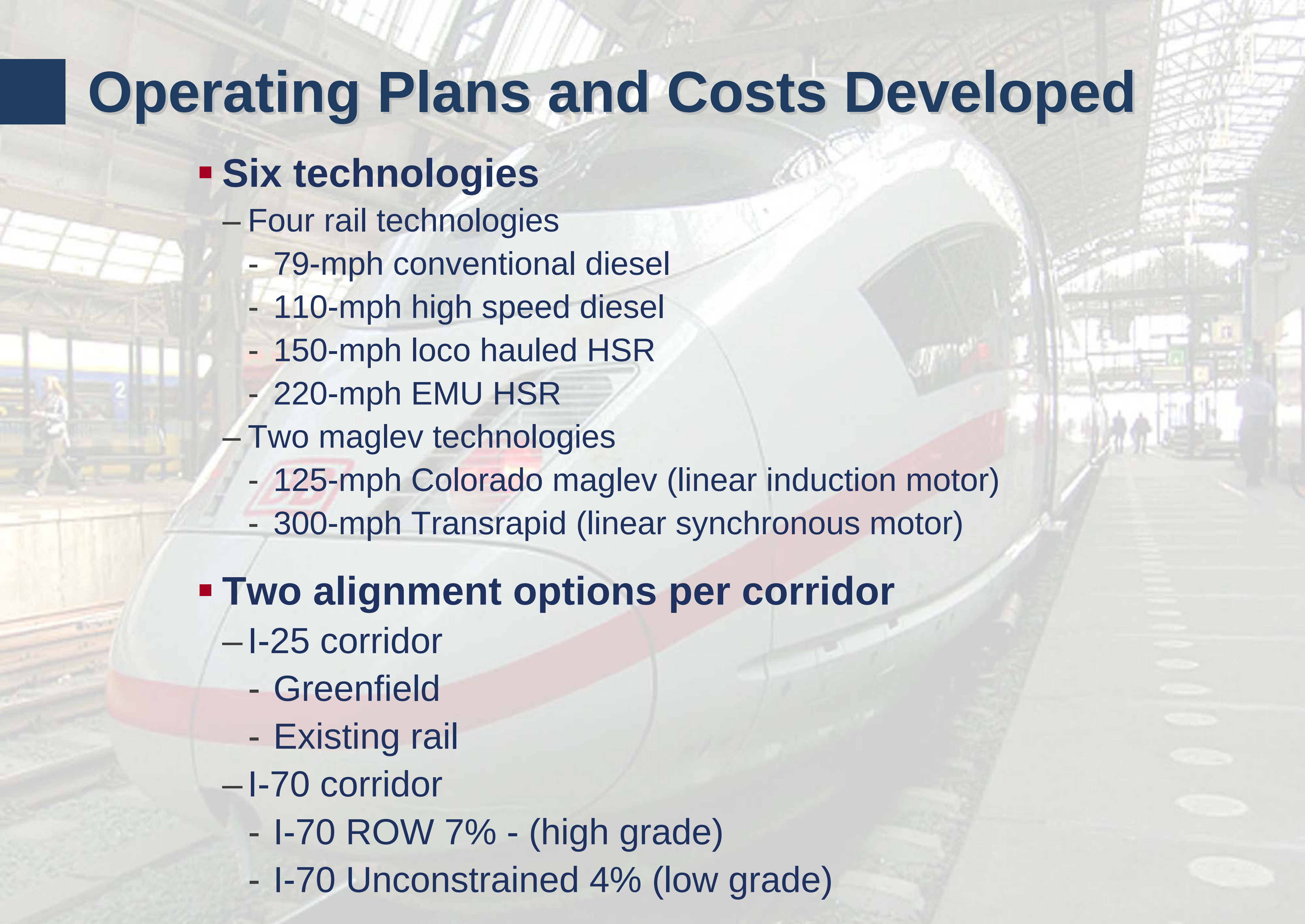


Key

ER: I-25 Existing Rail
GF: I-25 Greenfield
RW: I-70 Right of Way 7%
UC: I-70 Unconstrained 4%

46% of Capital generates 98% of Revenue

Operations and Operating Costs

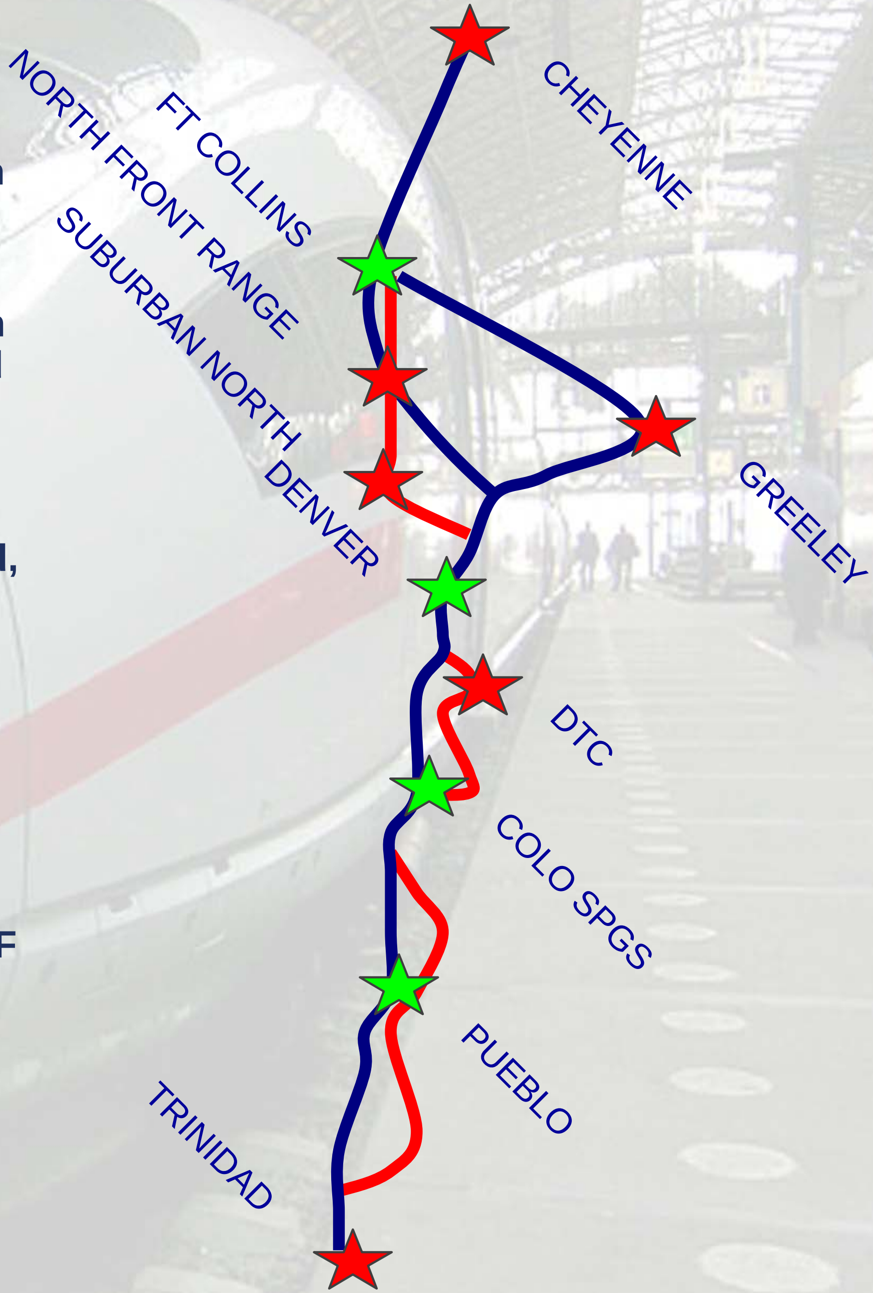


Operating Plans and Costs Developed

- **Six technologies**
  - Four rail technologies
    - 79-mph conventional diesel
    - 110-mph high speed diesel
    - 150-mph loco hauled HSR
    - 220-mph EMU HSR
  - Two maglev technologies
    - 125-mph Colorado maglev (linear induction motor)
    - 300-mph Transrapid (linear synchronous motor)
- **Two alignment options per corridor**
  - I-25 corridor
    - Greenfield
    - Existing rail
  - I-70 corridor
    - I-70 ROW 7% - (high grade)
    - I-70 Unconstrained 4% (low grade)

I-25 North and South

- Cheyenne to Fort Collins – Weak demographics limit what can be done north of Fort Collins, but perhaps a limited service may be possible based on the strength of I-70 connections.
- Fort Collins to Denver Greenfield – The Greenfield's Suburban North station on I-25/E-470 is closer to Boulder/Longmont and picks up stronger ridership, than does the alternative using existing rail.
- Fort Collins to Denver Existing Rail – Milliken line's North Front Range station near Loveland, shared with the Greenfield, is very strong. The Milliken Line is also shorter than via Greeley, but using it would require constructing a new Greenfield connection.
- Denver to Pueblo Greenfield – Adds a second strong South Suburban station at DTC that drives up ridership. Serving Monument is difficult.
- Denver to Pueblo Existing Rail – Would establish a dedicated track by using one of the two existing separate rail lines (ATSF alignment.) Potential problem areas Denver to Littleton, and from Palmer Lake through Colorado Springs.
- Pueblo to Trinidad – Although the existing Rail line would be very lightly used if R2C2 occurs but local market demographics don't appear to be strong enough to support a Corridor rail service. A through service to Albuquerque may be possible but not in scope of the current study.



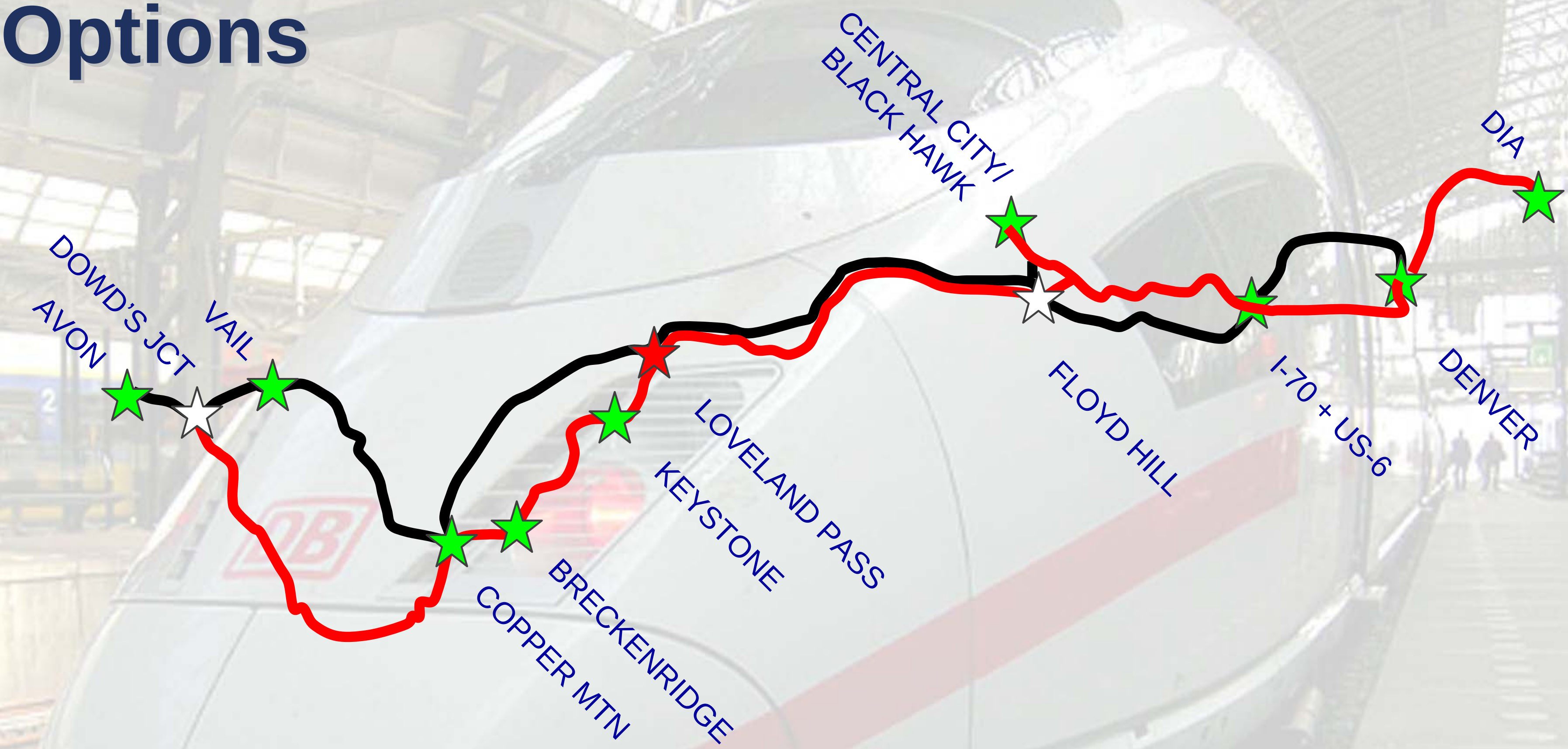
I-25 North – Preliminary Operational Assessment: Time and Average Speed

Technology								
Description		79-mph Existing Rail Non tilting	110-mph Existing Rail Tilting	125-mph 7% RW	150-mph 4% UC Tilting	220-mph 7% RW Non tilting	220-mph 7% RW Tilting	300-mph 7% RW
SUMMARY Cheyenne - to - Denver	***Best Combo*** 114 mi	***2:05*** *55 mph*	***1:27*** *79 mph*	***1:15*** *91 mph*	***1:15*** *91 mph*	***1:13*** *94 mph*	***1:07*** *102 mph*	***1:05*** *105 mph*
Cheyenne - to - Fort Collins	**BNSF** 46 mi	0:53	0:38	-	0:35	-	-	-
	Via I-25 46 mi	-	-	0:30	-	0:28	0:25	0:23
Fort Collins - to - Denver	**Greeley** 76 mi	1:21	0:55	-	0:45	-	-	-
	Milliken 68 mi	1:12	0:49	-	0:40	-	-	-
	I-25 68 mi	1:12	0:49	0:45	-	0:45	0:42	0:42
	Boulder 72 mi	1:56	1:22	-	1:19	-	-	-

I-25 South – Preliminary Operational Assessment: Time and Average Speed

Technology								
Description		79-mph Existing Rail Non tilting	110-mph Existing Rail Tilting	125-mph 7% RW	150-mph 4% UC Tilting	220-mph 7% RW Non tilting	220-mph 7% RW Tilting	300-mph 7% RW
SUMMARY Denver - to - Trinidad	***Joint Line*** 210 mi ***Greenfield*** 231 mi	***4:30*** *47 mph*	***2:55*** *72 mph*	***2:17*** *101 mph*	***2:40*** *79 mph*	***2:05*** *111 mph*	***2:00*** *116 mph*	***1:45*** *132 mph*
Denver - to - Colo Springs	**Joint Line** 72 mi	1:45	1:05	-	0:58	-	-	-
	Greenfield 97 mi	-	-	0:47	-	0:45	0:44	0:40
Colo Springs - to - Pueblo	**Joint Line** 46 mi	1:00	0:35	-	0:32	-	-	-
	Greenfield 48 mi	-	-	0:30	-	0:29	0:27	0:25
Pueblo - to - Trinidad	**Joint Line** 92 mi	1:45	1:15	-	1:10	-	-	-
	Greenfield 86 mi	-	-	1:00	-	0:51	0:49	0:40

I-70 East of Avon– Comparative Route Options



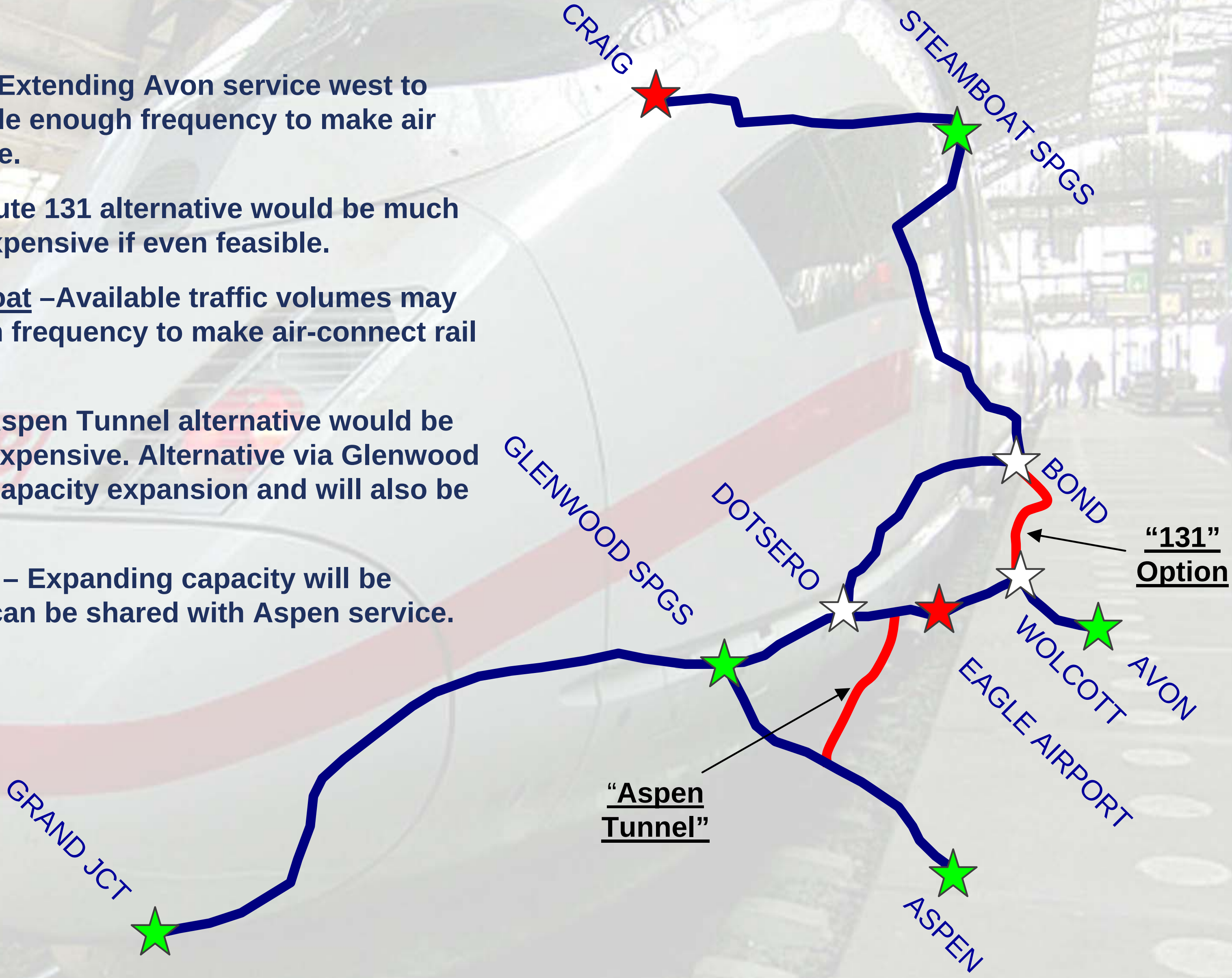
- **DIA to Denver – Follow Brush Line and Greenfield to DIA Airport**
- **Denver to US-6/I-70 – US-6 is the fastest alignment but probably also the most expensive.**
- **US-6/I-70 to Floyd Hill – Choice between heavy grades via El Rancho or sharp curves/tunnels in the Clear Creek canyon.**
- **Floyd Hill to Loveland Pass – "Corridor"alignment parallels I-70 with better grades using a tunnel up to Silver Plume.**
- **Loveland Pass to Copper – "Greenfield" alignment south of Dillon Lake serves Keystone and Breckenridge directly.**
- **Copper to Dowd's– I-70 over Vail Pass has steep grades; Pando alternative needs a branch line to Vail.**
- **Dowd's Jct to Avon –Existing rail to Avon.**

I-70 East of Avon – Preliminary Operational Assessment: Time and Average Speed

Technology						
Description		125-mph 7% RW	150-mph 4% UC Tilting	220-mph 7% RW Non tilting	220-mph 7% RW Tilting	300-mph 7% RW
SUMMARY* *DIA* *- to -* *Avon	*I-70* 135 mi	***2:13*** *61 mph*	***2:25*** *56 mph*	***2:36*** *52 mph*	***2:25*** *56 mph*	***2:10*** *62 mph*
DIA - to - Denver	**BNSF** 23 mi	0:16	0:13	0:14	0:13	0:13
Denver - to - Copper	**I-70** 80 mi	1:20	1:30	1:35	1:30	1:20
Copper - to - Vail	**I-70** 22 mi	0:25	0:27	0:30	0:27	0:25
Vail - to - Avon	**UP RR** 10 mi	0:12	0:15	0:17	0:15	0:12
Denver - to - Black Hawk	**US-6** 35 mi	0:53	0:54	1:00	0:54	0:53

I-70 West of Avon– Route Options

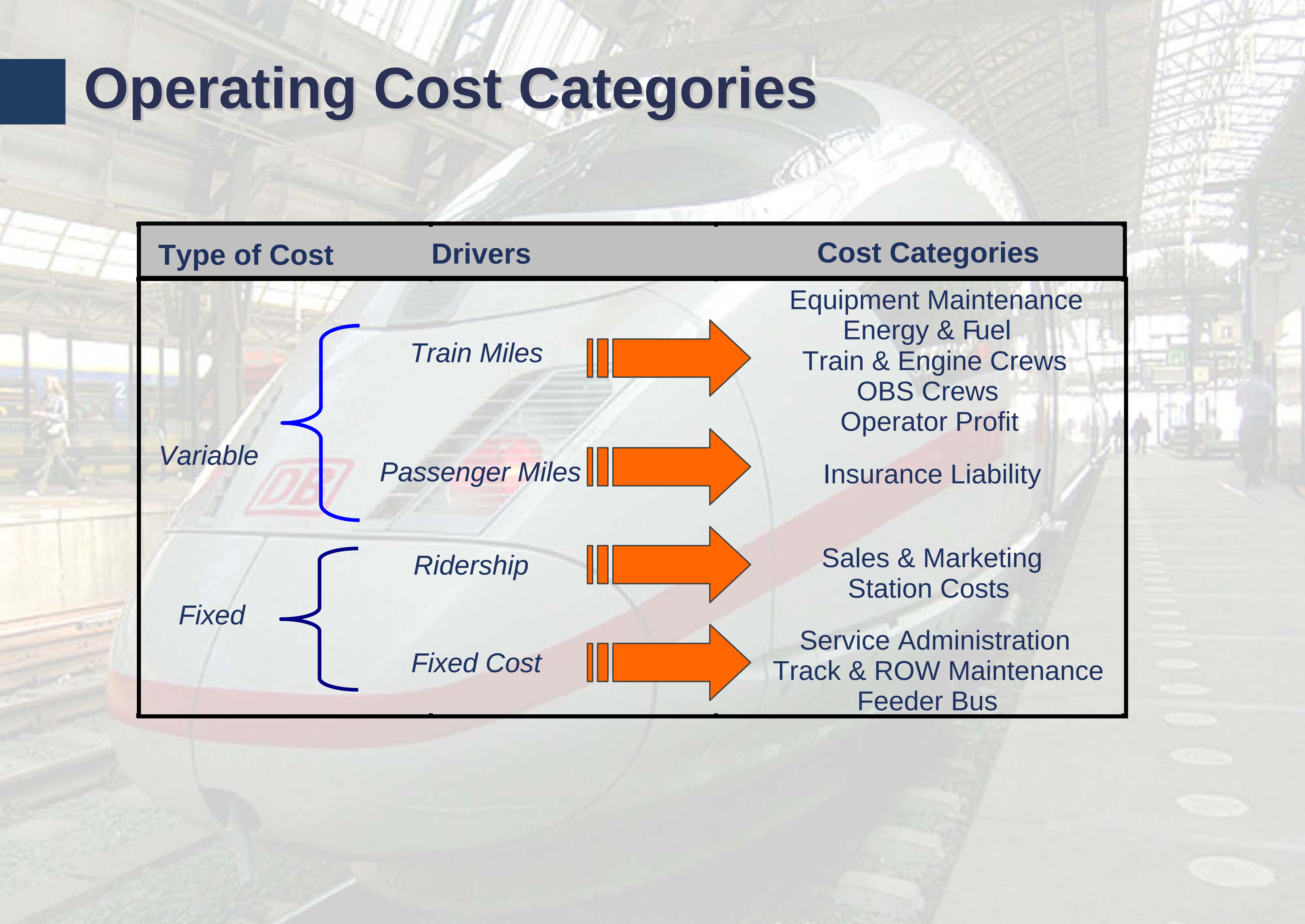
- **Eagle Airport to Avon** – Extending Avon service west to Eagle would likely provide enough frequency to make air connect service attractive.
- **Avon to Steamboat** – Route 131 alternative would be much faster, but will be very expensive if even feasible.
- **Eagle Airport to Steamboat** –Available traffic volumes may not support enough train frequency to make air-connect rail service attractive.
- **Avon/Eagle to Aspen** – Aspen Tunnel alternative would be much faster but is very expensive. Alternative via Glenwood Canyon requires UPRR capacity expansion and will also be expensive.
- **Avon/Eagle to Grand Jct** – Expanding capacity will be expensive, but the cost can be shared with Aspen service.



I-70 West of Avon – Preliminary Operational Assessment: Time and Average Speed

Technology						
Description		125-mph 7% RW	150-mph 4% UC Tilting	220-mph 7% RW Non tilting	220-mph 7% RW Tilting	300-mph 7% RW
Avon - to - Grand Jct	UP RR 141 mi	1:42 *83 mph*	1:45 *81 mph*	1:55 *74 mph*	1:45 *81 mph*	1:37 *87 mph*
Avon - to - Glenwood	UP RR 52 mi	0:42	0:45	0:50	0:45	0:42
Glenwood - to - Grand Jct	UP RR 89 mi	1:00	1:00	1:05	1:00	0:55
Avon - to - Steamboat	Wolcott 90 mi	1:20	1:30	1:40	1:30	1:20
	Dotsero 133 mi	2:10	2:15	2:25	2:15	2:10
Avon - to - Aspen	UP RR 89 mi	1:15	1:22	1:38	1:22	1:15
	Tunnel 65 mi	0:50	0:53	1:00	0:53	0:50

Operating Cost Categories



Type of Cost	Drivers	Cost Categories
Variable	*Train Miles*	Equipment Maintenance Energy & Fuel Train & Engine Crews OBS Crews Operator Profit
	Passenger Miles	Insurance Liability
Fixed	*Ridership*	Sales & Marketing Station Costs
	Fixed Cost	Service Administration Track & ROW Maintenance Feeder Bus

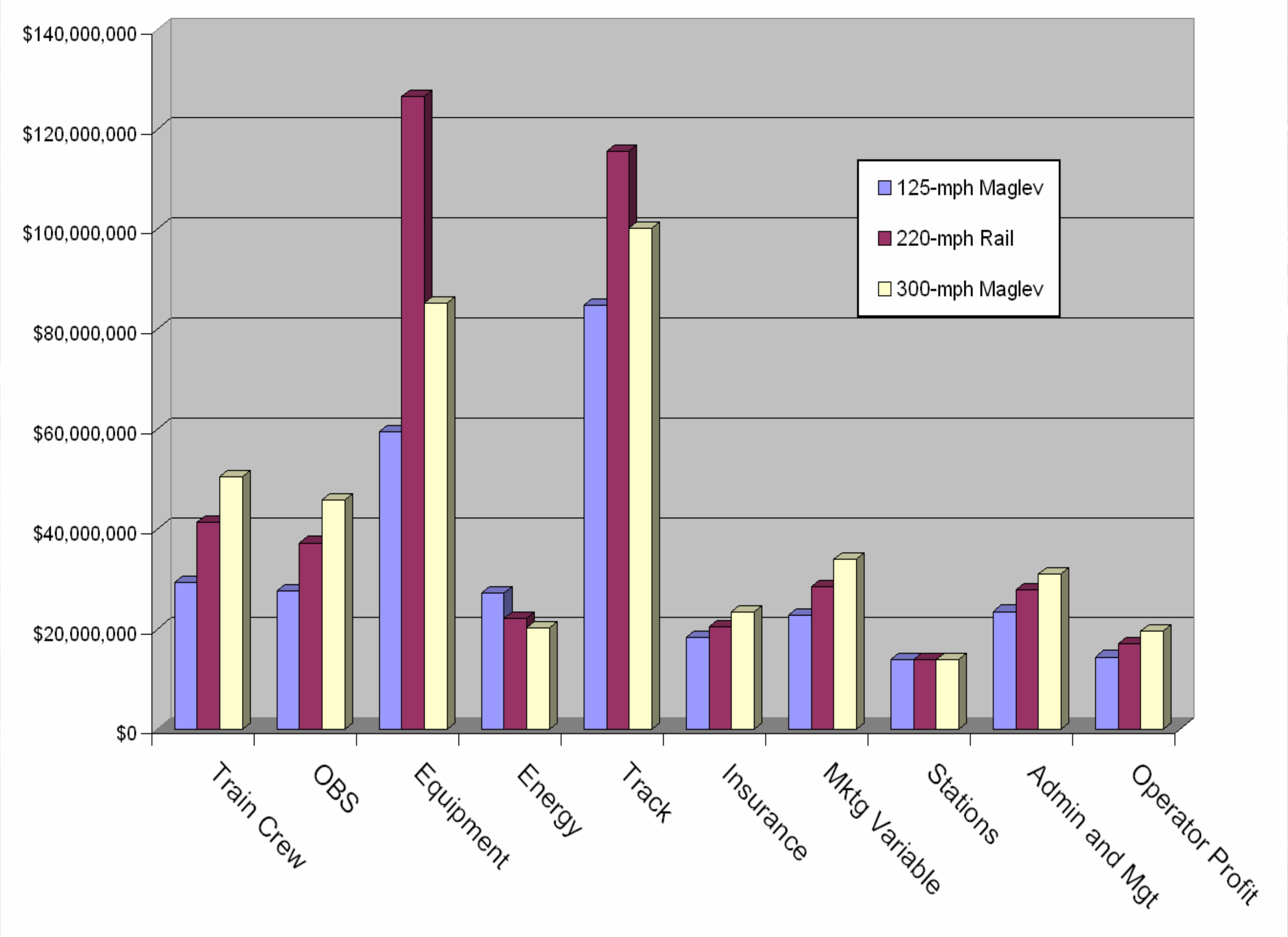
Operating Cost Comparison

- Costs that depend on technology/speed/demand are estimated to reflect differences
- Costs that reflect overhead/administration/insurance/crews are treated the same.

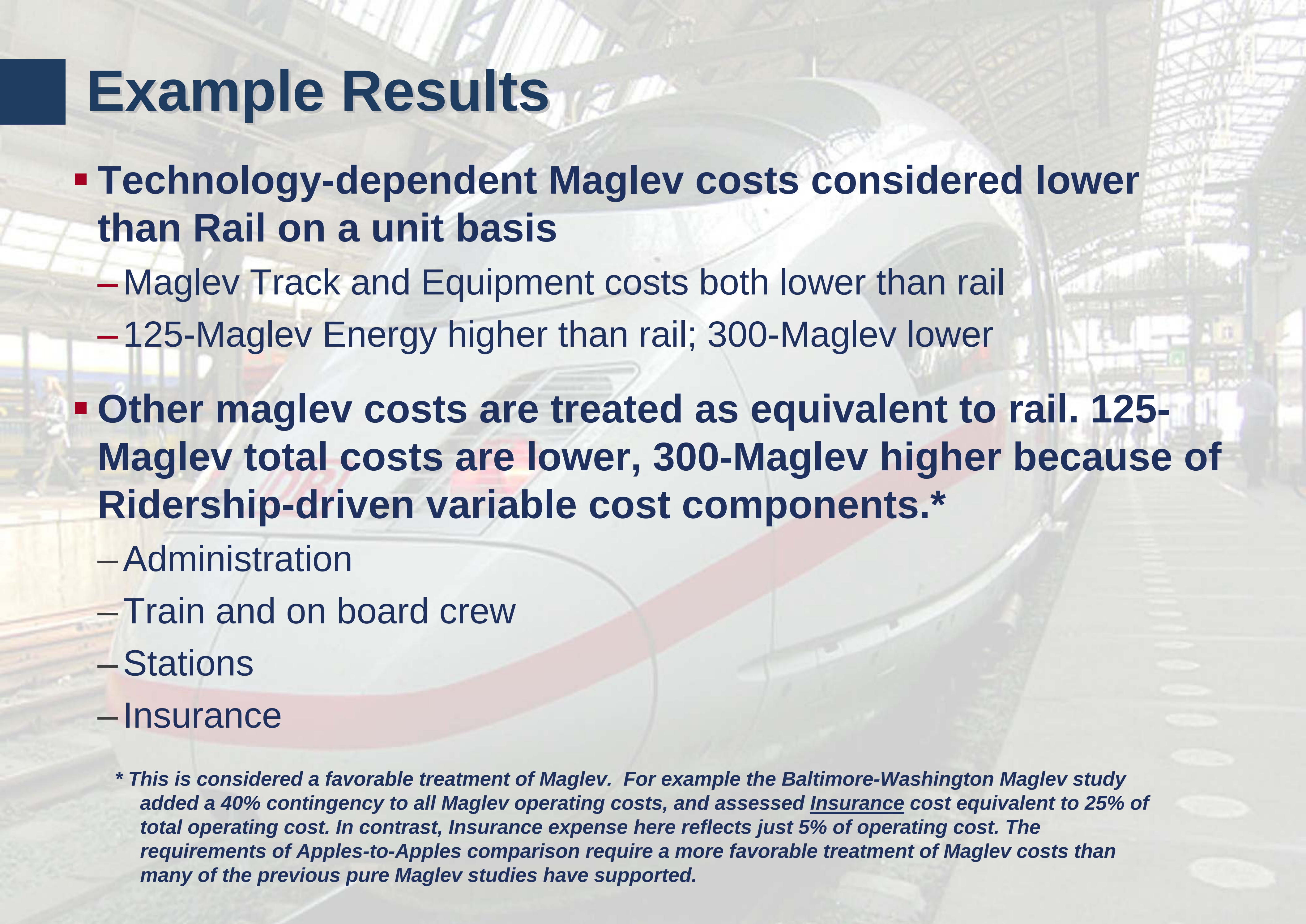
Maglev vs. Rail Operating Cost Comparison

I-70 ROW (7%) + I-25 Greenfield Network, Year 2025 Projection

Example Results



Example Results



- **Technology-dependent Maglev costs considered lower than Rail on a unit basis**
  - Maglev Track and Equipment costs both lower than rail
  - 125-Maglev Energy higher than rail; 300-Maglev lower
- **Other maglev costs are treated as equivalent to rail. 125-Maglev total costs are lower, 300-Maglev higher because of Ridership-driven variable cost components.***
  - Administration
  - Train and on board crew
  - Stations
  - Insurance

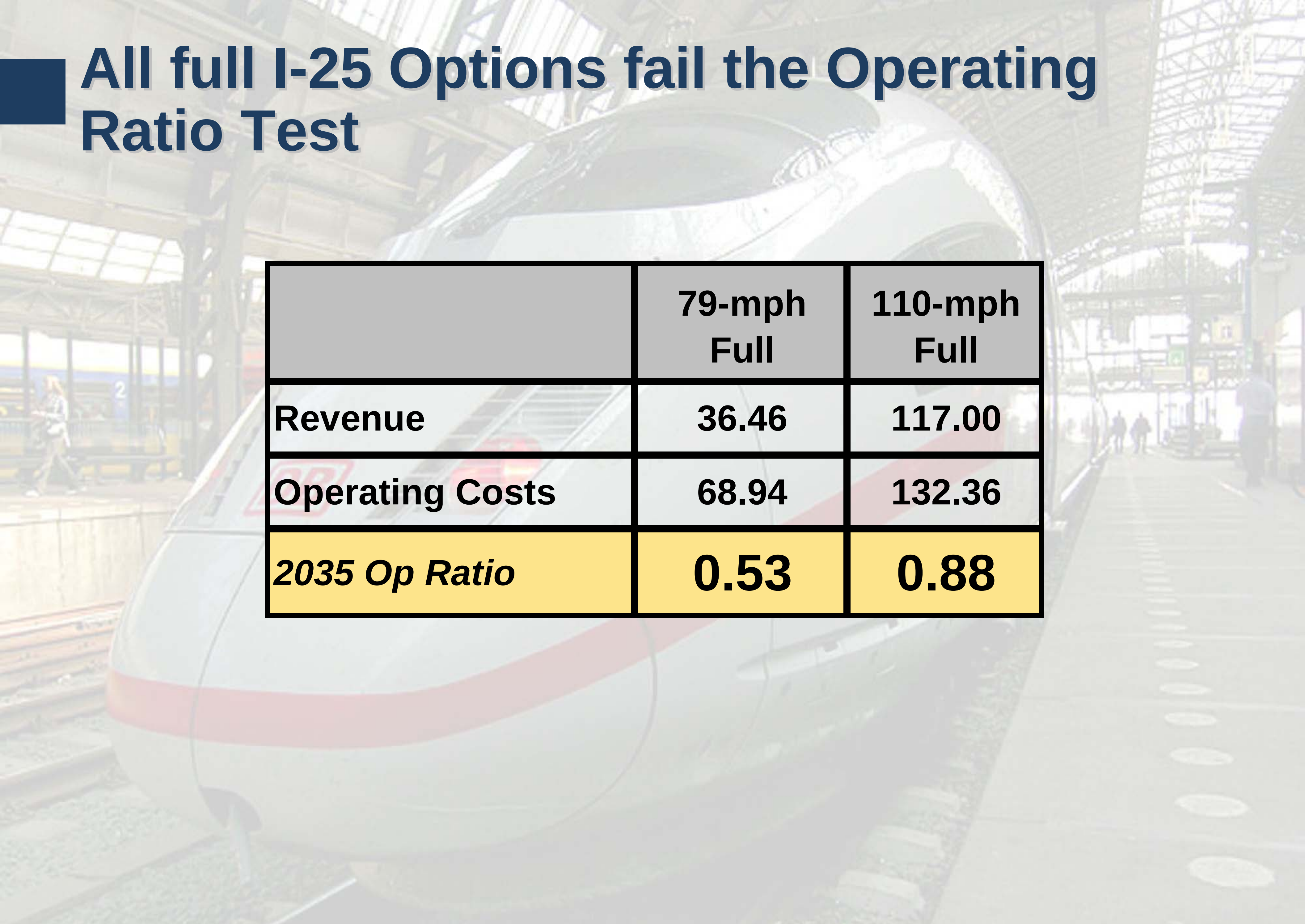
**** This is considered a favorable treatment of Maglev. For example the Baltimore-Washington Maglev study added a 40% contingency to all Maglev operating costs, and assessed Insurance cost equivalent to 25% of total operating cost. In contrast, Insurance expense here reflects just 5% of operating cost. The requirements of Apples-to-Apples comparison require a more favorable treatment of Maglev costs than many of the previous pure Maglev studies have supported.***

Ridership, Revenue, Cost & Operation Questions

Preliminary Financial Analysis

Find a "Sweet Spot" that achieves a Positive Operating ratio (>1.0) without spending too much Capital up-front.

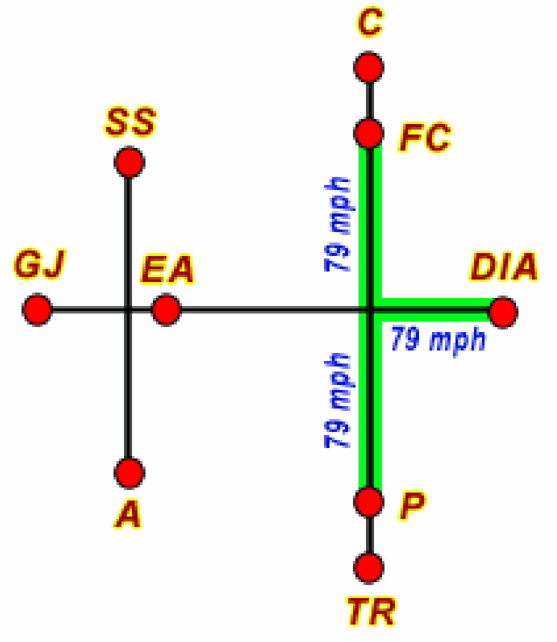
All full I-25 Options fail the Operating Ratio Test

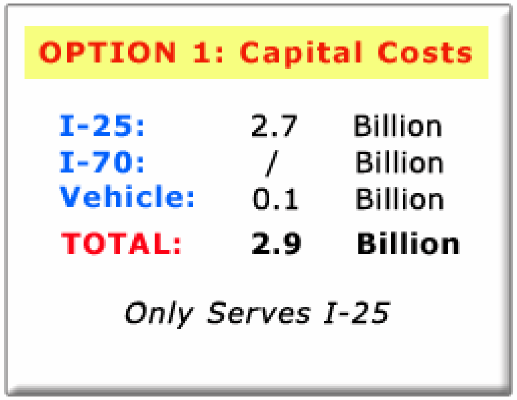


	79-mph Full	110-mph Full
Revenue	**36.46**	**117.00**
Operating Costs	**68.94**	**132.36**
2035 Op Ratio	**0.53**	**0.88**

79-mph/110-mph Existing Rail Truncated Phase 1 Alternatives

Option 1: 79-mph

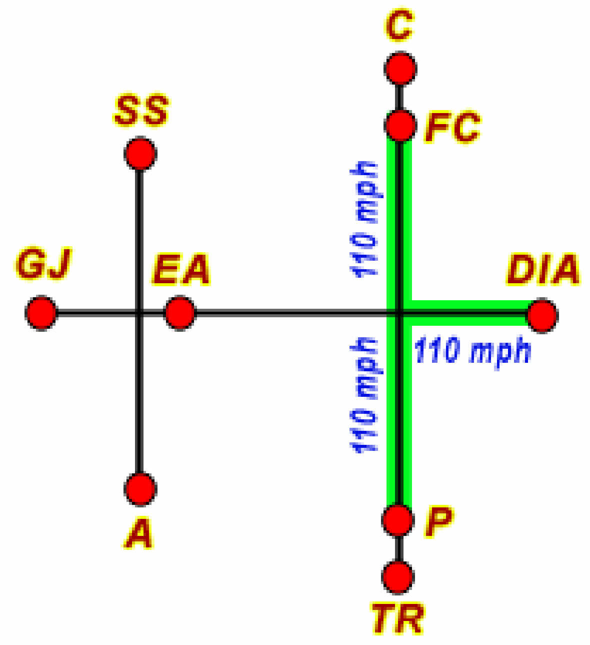


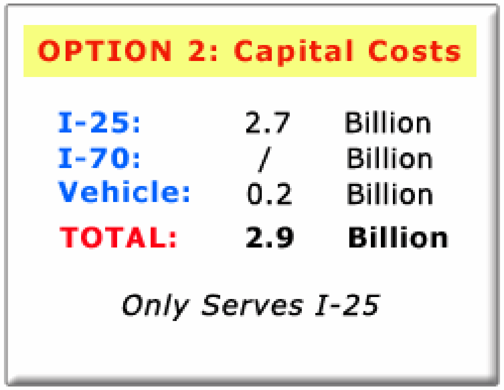

OPTION 1: Capital Costs

I-25:	2.7	Billion
I-70:	/	Billion
Vehicle:	0.1	Billion
TOTAL:	**2.9**	**Billion**

Only Serves I-25

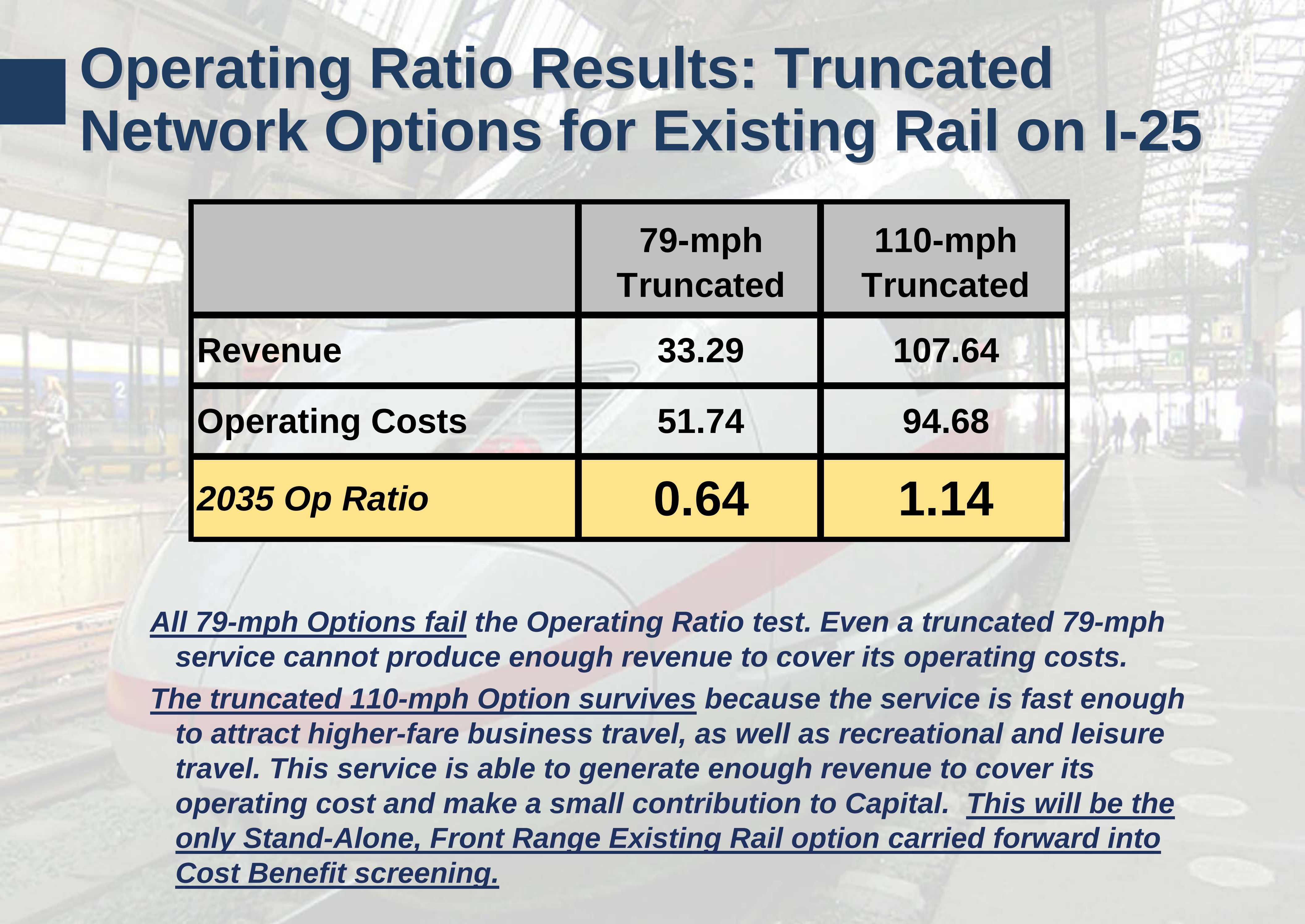
Option 2: 110-mph




OPTION 2: Capital Costs

I-25:	2.7	Billion
I-70:	/	Billion
Vehicle:	0.2	Billion
TOTAL:	**2.9**	**Billion**

Only Serves I-25



Operating Ratio Results: Truncated Network Options for Existing Rail on I-25

	79-mph Truncated	110-mph Truncated
Revenue	**33.29**	**107.64**
Operating Costs	**51.74**	**94.68**
2035 Op Ratio	**0.64**	**1.14**

***All 79-mph Options fail** the Operating Ratio test. Even a truncated 79-mph service cannot produce enough revenue to cover its operating costs.*

The truncated 110-mph Option survives** because the service is fast enough to attract higher-fare business travel, as well as recreational and leisure travel. This service is able to generate enough revenue to cover its operating cost and make a small contribution to Capital. **This will be the only Stand-Alone, Front Range Existing Rail option carried forward into Cost Benefit screening.

Operating Ratio Results: Full-Network Options using I-25 and I-70

	125-mph (7% Grade) Full	150-mph (4% Grade) Full	220-mph (7% Grade) Full	300-mph (7% Grade) Full
Revenue	**600.66**	**586.33**	**795.79**	**893.10**
Operating Costs	**373.10**	**416.09**	**484.43**	**448.38**
2035 Op Ratio	**1.61**	**1.41**	**1.64**	**1.99**

***All I-70 and I-25 Full Network Options Pass* the Operating Ratio test, even though some segments are lightly used.**

Contribution from the main line segments is sufficient to offset losses on some lightly used pieces.

Preliminary Economic Analysis

Process for Developing Alternatives

FRA criteria are being applied to assess the Economic Feasibility of each alternative, in a four-step process, as follows:

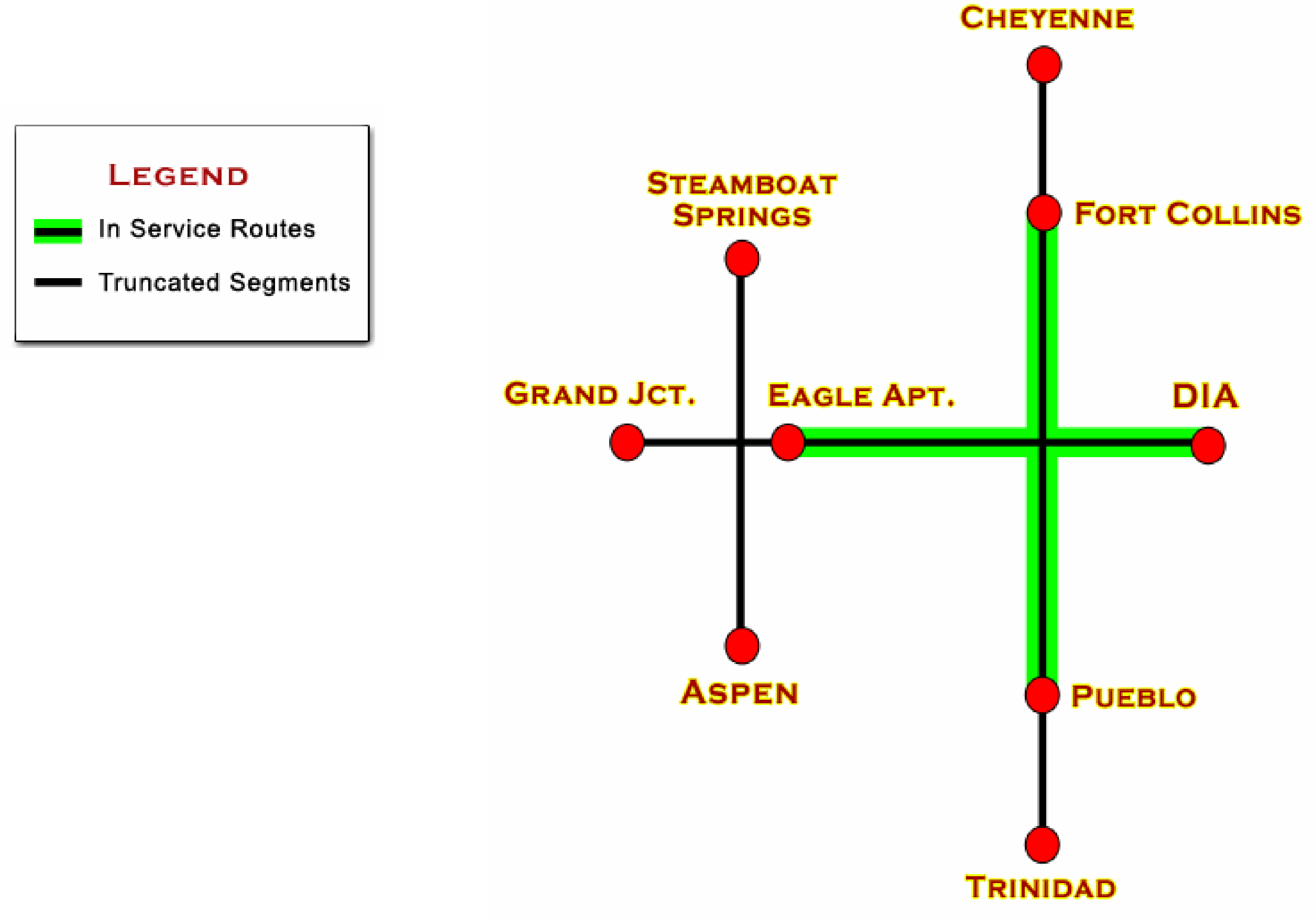
1. **“Initial” alternatives** follow the matrix displayed earlier
2. **“Truncated” alternatives** were developed that reduce costs by eliminating service north of Fort Collins, south of Pueblo, and west of Eagle County Airport.
3. **To further develop choices, “Mix and Match” networks were developed that combine different technologies** on different portions of the network, to restore some level of service to some of the cities that were “truncated” in Step 2, as well as to further improve the economic performance of the system.
4. **Stakeholder input is needed to ensure that all reasonable options have been screened in Steps 1-3.** The best alternative(s) will be taken forward for further evaluation.

Preliminary Economic Evaluation of Full Network Alternatives – 2035 – Central Case (millions of dollars)

	79-mph ER Full	110-mph ER Full	125-mph 7%/GF Full	150-mph 4%/ER Full	220-mph 7%/GF Full	300-mph 7%/GF Full
BENEFITS	1a/b	2a/b	3a	4	5b	6a
Revenue	36.46	117.00	600.66	586.33	795.79	893.10
Consumer Surplus	7.74	117.45	513.80	543.87	720.81	682.55
Resource Savings	3.39	72.66	312.18	312.18	390.22	444.05
Total Benefits	47.59	307.1124	1426.639	1442.379	1906.824	2019.698
COSTS						
Operating Costs	68.94	132.36	373.10	416.09	484.43	448.38
Capital Costs	230.74	237.22	4241.84	1799.59	2255.20	4827.45
Total Costs	299.68	369.58	4614.94	2215.68	2739.63	5275.83
Cost Benefit Ratio	**0.16**	**0.83**	**0.31**	**0.65**	**0.70**	**0.38**

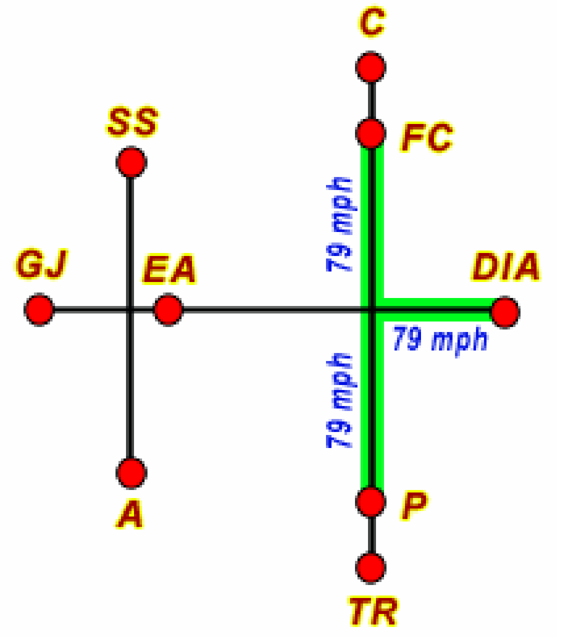
All Full Network options fail ***the first-cut Cost Benefit test, because of low density line segments south of Pueblo, north of Fort Collins and west of Eagle.***

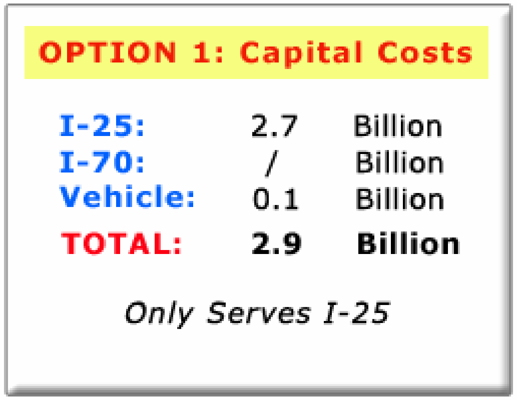
Development of Truncation Options for I-70 and I-25 Corridors



79-mph/110-mph Existing Rail Truncated Phase 1 Alternatives

Option 1: 79-mph



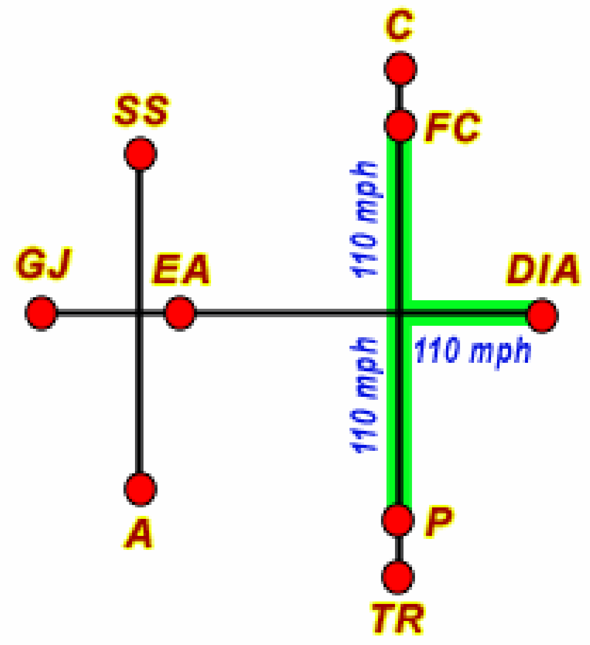


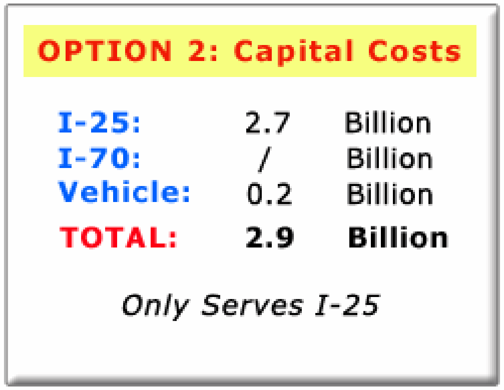
OPTION 1: Capital Costs

I-25:	2.7	Billion
I-70:	/	Billion
Vehicle:	0.1	Billion
TOTAL:	**2.9**	**Billion**

Only Serves I-25

Option 2: 110-mph





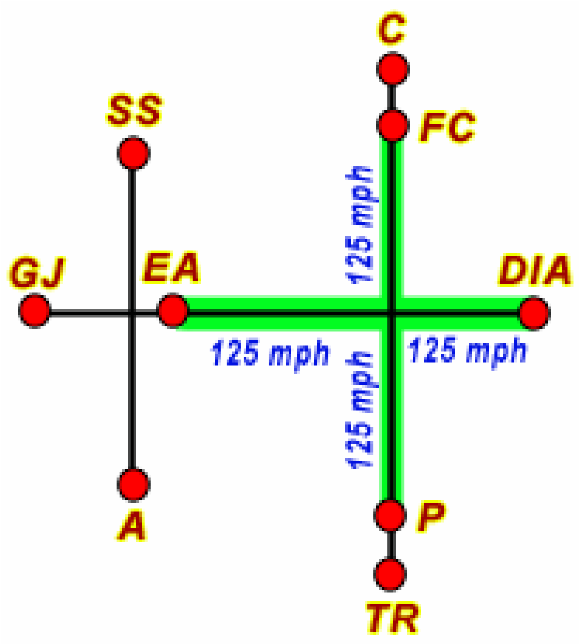
OPTION 2: Capital Costs

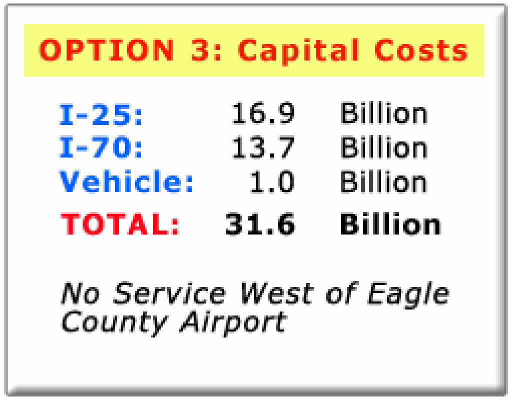
I-25:	2.7	Billion
I-70:	/	Billion
Vehicle:	0.2	Billion
TOTAL:	**2.9**	**Billion**

Only Serves I-25

125-mph/150-mph Truncated Phase 1 Alternatives

Option 3: 125-mph (7% GF)



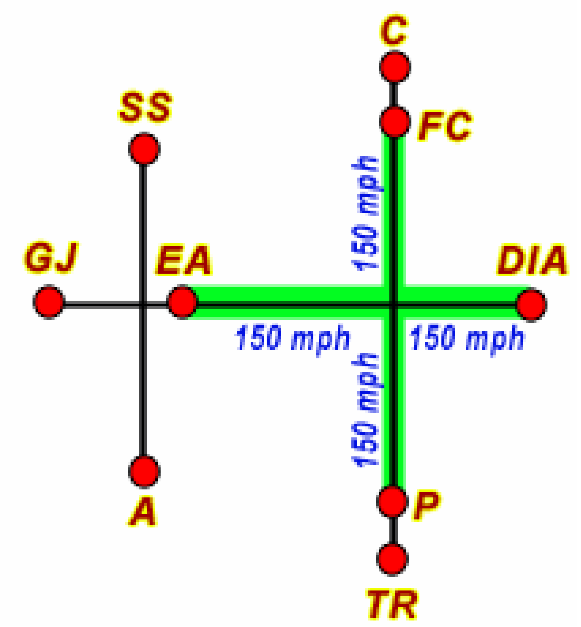


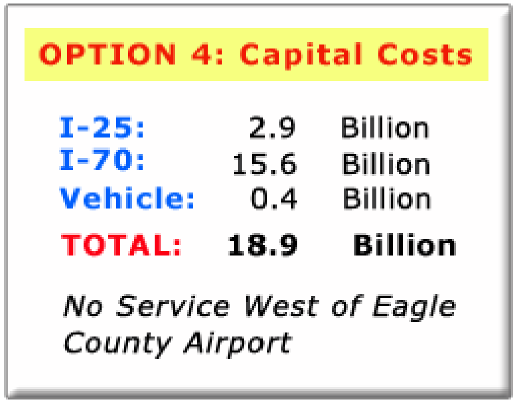
OPTION 3: Capital Costs

I-25:	16.9	Billion
I-70:	13.7	Billion
Vehicle:	1.0	Billion
TOTAL:	**31.6**	**Billion**

No Service West of Eagle County Airport

Option 4: 150-mph (4% ER)





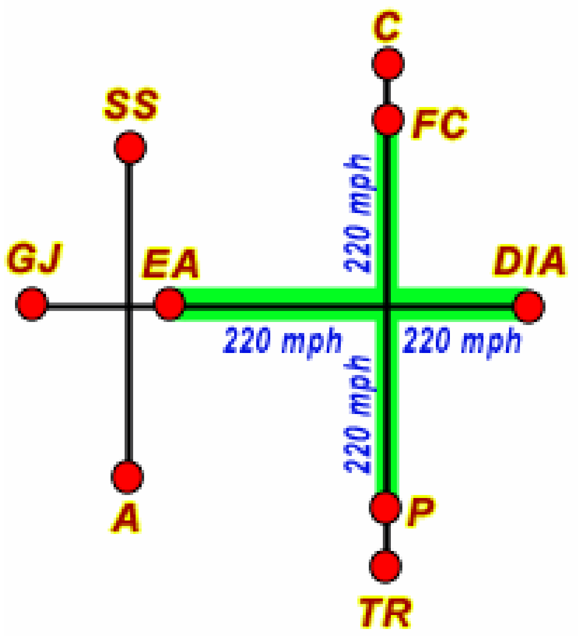
OPTION 4: Capital Costs

I-25:	2.9	Billion
I-70:	15.6	Billion
Vehicle:	0.4	Billion
TOTAL:	**18.9**	**Billion**

No Service West of Eagle County Airport

220-mph/300-mph Truncated Phase 1 Alternatives

Option 5: 220-mph (7% GF)

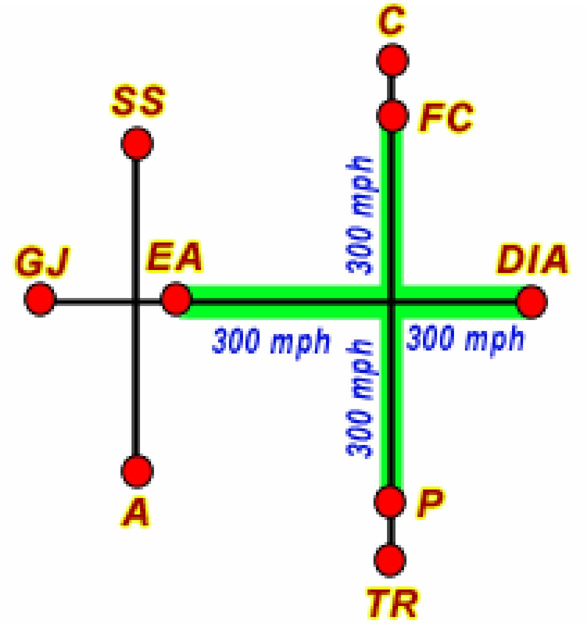


OPTION 5: Capital Costs

I-25:	6.0	Billion
I-70:	13.3	Billion
Vehicle:	0.6	Billion
TOTAL:	**19.9**	**Billion**

No Service West of Eagle County Airport

Option 6: 300-mph (7% GF)



OPTION 6: Capital Costs

I-25:	19.2	Billion
I-70:	15.6	Billion
Vehicle:	1.8	Billion
TOTAL:	**36.6**	**Billion**

No Service West of Eagle County Airport

Preliminary Economic Evaluation of Alternatives – 2035 – Central Case Truncated (millions of dollars)

	79-mph ER Trunc	110-mph ER Trunc	125-mph 7%/GF Trunc	150-mph 4%/ER Trunc	220-mph 7%/GF Trunc	300-mph 7%/GF Trunc
BENEFITS	1	2	3	4	5	6
Revenue	33.29	107.64	600.29	544.25	754.58	874.03
Consumer Surplus	7.07	112.23	792.95	700.02	960.66	955.30
Resource Savings	3.10	64.59	296.57	296.57	370.71	421.85
Total Benefits	43.45	284.46	1689.81	1540.84	2085.95	2251.18
COSTS						
Operating Costs	51.74	94.68	319.60	344.25	409.60	357.90
Capital Costs	173.75	178.64	1946.56	1164.24	1225.84	2254.56
Total Costs	225.49	273.32	2266.16	1508.49	1635.44	2612.46
Cost Benefit Ratio	0.19	1.04	0.75	1.02	1.28	0.86

All "Two Corridor" Maglev Options Fail ***the Cost Benefit test even after truncation, because of the high cost of Greenfield construction on the I-25 corridor. However, 300-mph Maglev does better than 125-mph Maglev. All rail options survive.***

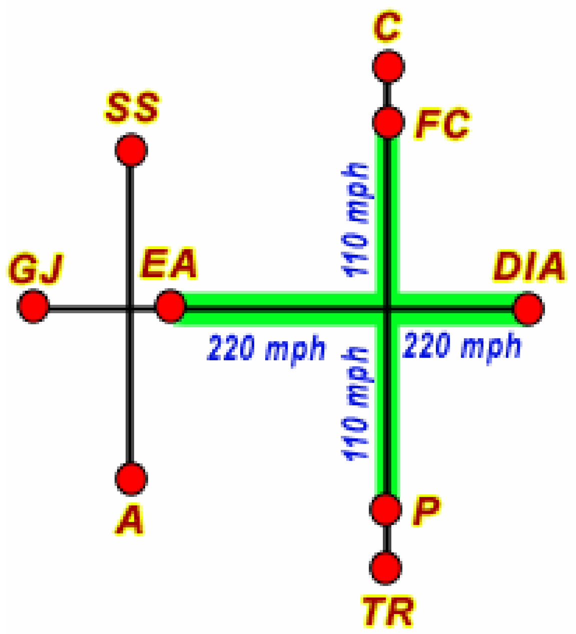
Development of Mix and Match Strategies –

Combinations of Technologies on Different Corridors

Mix and Match Phase 1 Alternatives

Option 7:

**220-mph (7% GF) w/
110-mph ER on I-25**



OPTION 7: Capital Costs

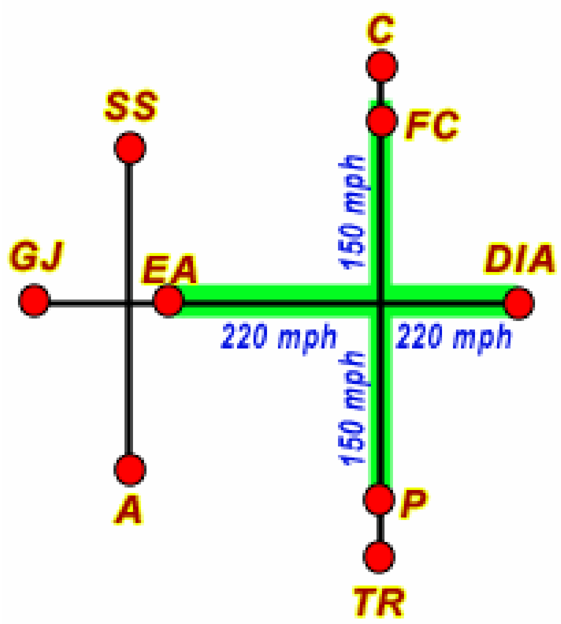
I-25:	2.5	Billion
I-70:	13.3	Billion
Vehicle:	0.5	Billion
TOTAL:	**16.3**	**Billion**

Transfer at Denver

No Service West of Eagle County Airport

Option 8:

**220-mph (7% GF) w/
150-mph ER on I-25**



OPTION 8: Capital Costs

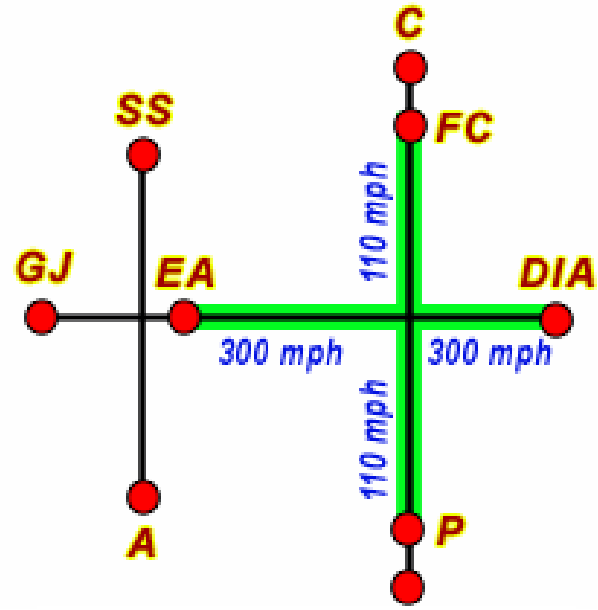
I-25:	2.9	Billion
I-70:	13.3	Billion
Vehicle:	0.6	Billion
TOTAL:	**16.8**	**Billion**

No Service West of Eagle County Airport

Mix and Match Phase 1 Alternatives

Option 9:

300-mph (7% GF) w/ 110-mph ER on I-25



OPTION 9: Capital Costs

I-25:	2.6	Billion
I-70:	15.6	Billion
Vehicle:	1.3	Billion
TOTAL:	**19.5**	**Billion**

Transfer at Denver

No Service West of Eagle County Airport

Preliminary Economic Evaluation of Alternatives – 2035 – Central Case Mix and Match (millions of dollars)

	Carry Fwd	New Mix and Match Alternatives		
	220-mph 7% / GF Trunc	110-mph ER T on I-25 w/ 220-mph 7% T on I-70	150-mph ER T on I-25 w/ 220-mph 7% T on I-70	110-mph ER T on I-25 w/ 300-mph 7% T on I-70
BENEFITS	5	7	8	9
Revenue	754.58	492.56	633.74	511.83
Consumer Surplus	960.66	646.2	717.76	609.29
Resource Savings	370.71	241.50	340.98	407.00
Total Benefits	2085.95	1380.26	1692.48	1528.12
COSTS				
Operating Costs	409.60	341.21	377.16	270.13
Capital Costs	1225.84	1010.24	1034.88	1201.20
Total Costs	1635.44	1351.45	1412.04	1471.33
Cost Benefit Ratio	1.28	1.02	1.20	1.04

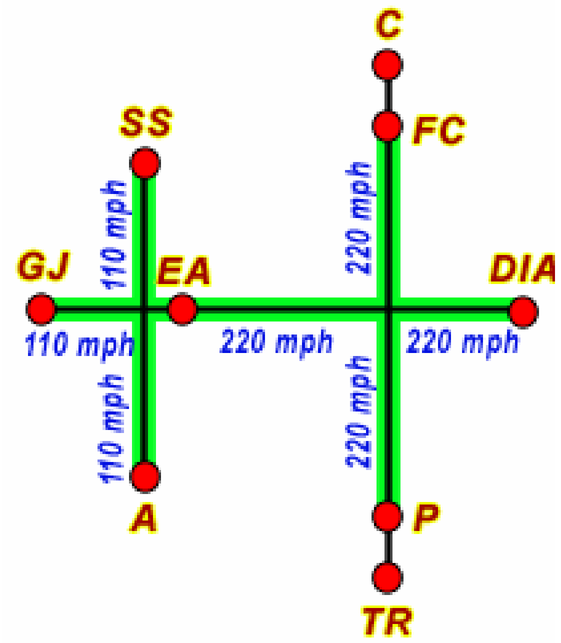
All Mix-and-Match Options Survive the Cost Benefit test, including one option for 300-mph Maglev on I-70. However, the All-Electric Rail options 5 and 8 perform best.

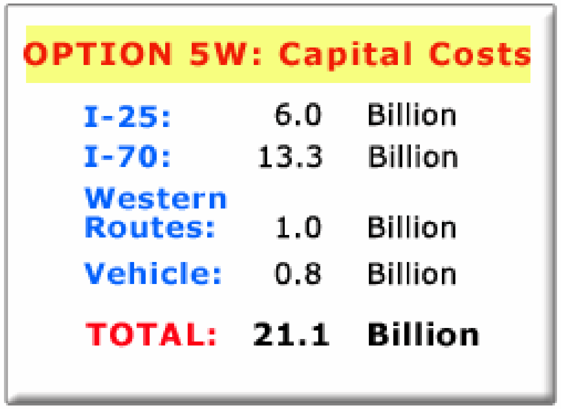
Western Expansion Rail Strategies

Attempt to restore a low-cost Diesel Rail service west of Eagle Airport – Hypothetical $1 Billion Max Capital Budget

Western Expansion
Phase 2 Alternatives: Option 1

Option 5W

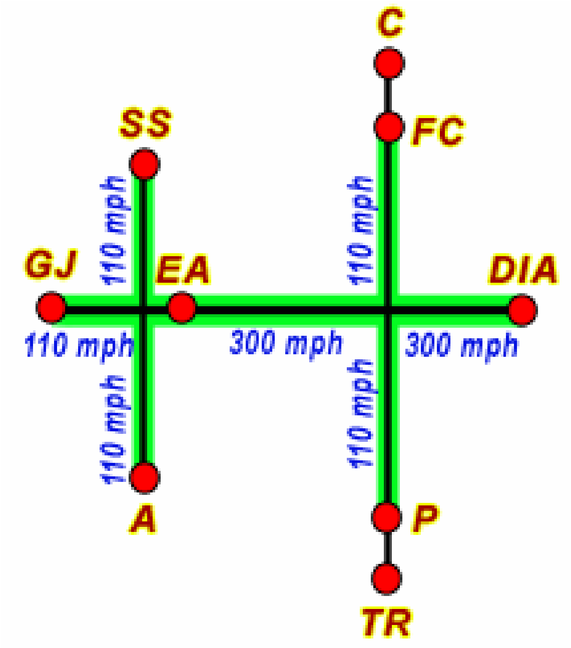


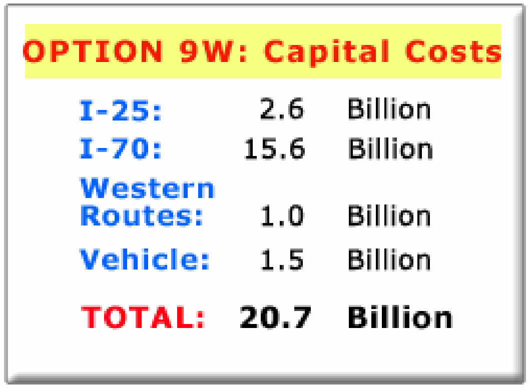


OPTION 5W: Capital Costs

I-25:	6.0	Billion
I-70:	13.3	Billion
Western Routes:	1.0	Billion
Vehicle:	0.8	Billion
TOTAL:	**21.1**	**Billion**

Option 9W





OPTION 9W: Capital Costs

I-25:	2.6	Billion
I-70:	15.6	Billion
Western Routes:	1.0	Billion
Vehicle:	1.5	Billion
TOTAL:	**20.7**	**Billion**

Preliminary Economic Evaluation of Alternatives – 2035 – Central Case Western Expansion Alternatives Phase 3 (millions of dollars)

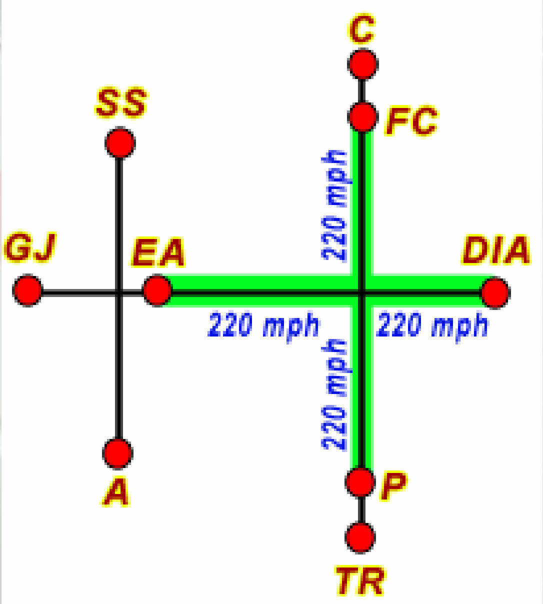
Both Western Expansion Options Survive the Cost Benefit test.

220-mph Electric Rail does better because it can provide a seamless one-seat ride in the I-25 corridor. Maglev remains viable for the I-70 core because of its strong ridership appeal.

	220-mph 7% / GF Trunc w 110 W of Eagle	300-mph 7% on I-70 w/110 on I-25 and W of Eagle
BENEFITS	**5W**	**9W**
Revenue	**781.27**	**569.18**
Consumer Surplus	**980.08**	**637.37**
Resource Savings	**380.67**	**430.78**
Total Benefits	**2142.02**	**1637.33**
COSTS		
Operating Costs	**469.60**	**320.13**
Capital Costs	**1299.76**	**1275.12**
Total Costs	**1769.36**	**1595.25**
Cost Benefit Ratio	**1.21**	**1.03**

Recommendations and Conclusions

- **Recommend to Remove**
  - 79-mph Rail: Operating Subsidy, Poor Cost/Benefit Ratio
  - 125-mph Maglev: Poor Cost/Benefit Ratio
  - Truncated I-25 Segments, Poor Cost/Benefit Ratio
- **Recommended to Retain for Optimization and Detailed Analysis:**
  - 220-mph (5W) Electric on both I-25 and I-70
    - ☐ Meets all FRA Economic and Financial Criteria
    - ☐ Provides single-seat ride between I-70 and I-25
    - ☐ Determine costs of completely avoiding freight ROW
    - ☐ Consider some 110-mph Western Extensions

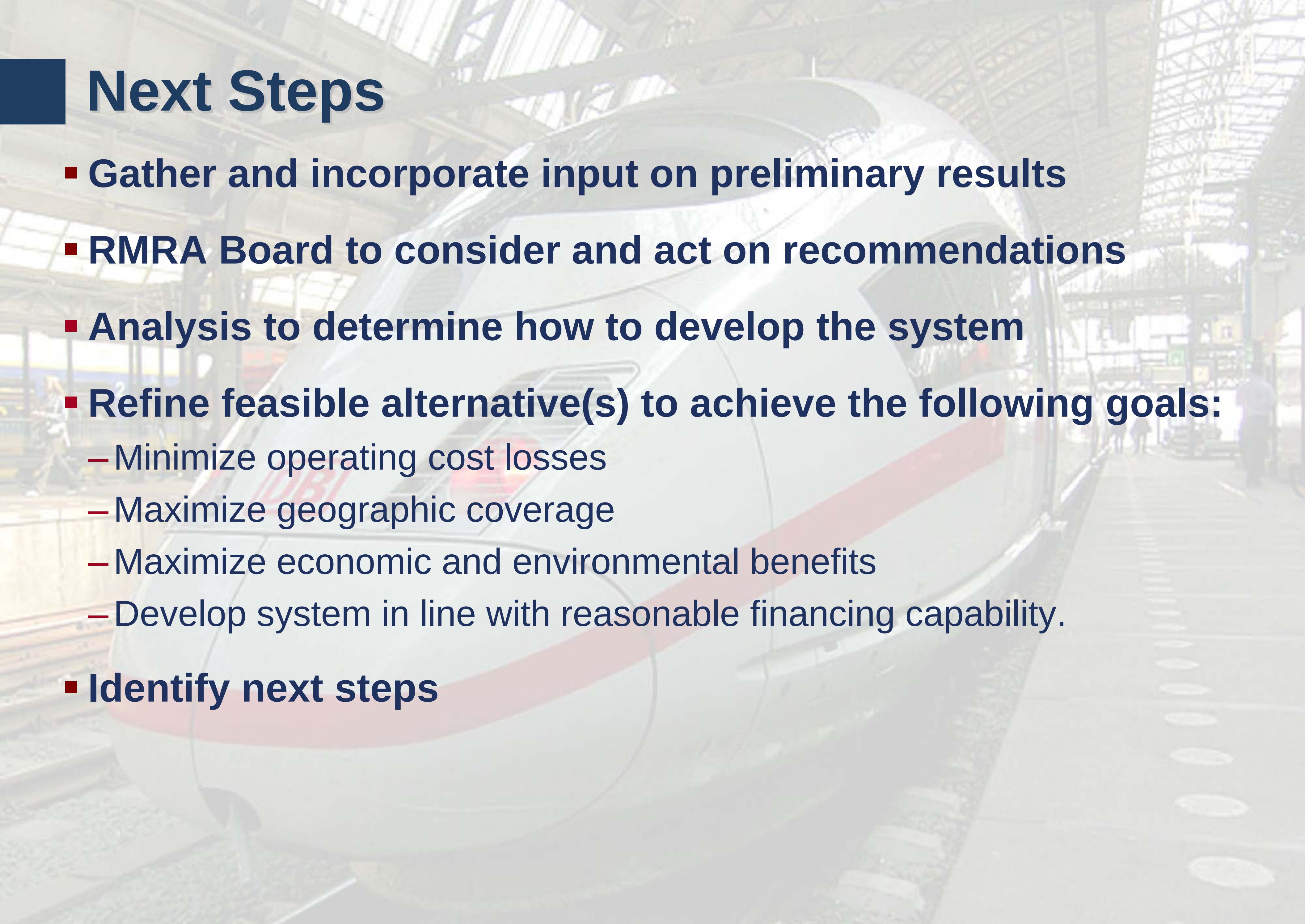


OPTION 5: Capital Costs

I-25:	6.0	Billion
I-70:	13.3	Billion
Vehicle:	0.6	Billion
TOTAL:	**19.9**	**Billion**

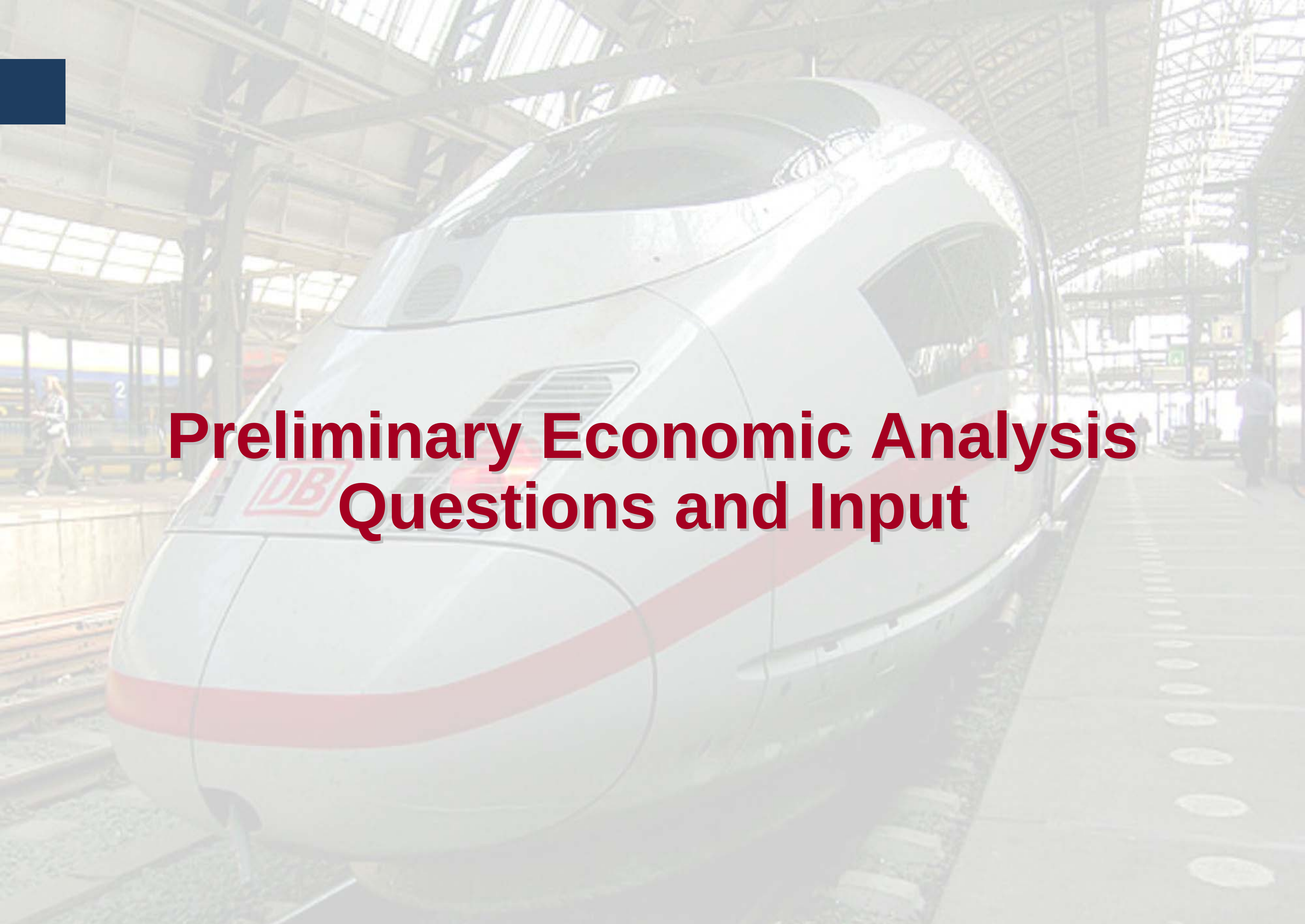
No Service West of Eagle County Airport

Next Steps



Next Steps

- **Gather and incorporate input on preliminary results**
- **RMRA Board to consider and act on recommendations**
- **Analysis to determine how to develop the system**
- **Refine feasible alternative(s) to achieve the following goals:**
  - Minimize operating cost losses
  - Maximize geographic coverage
  - Maximize economic and environmental benefits
  - Develop system in line with reasonable financing capability.
- **Identify next steps**



Preliminary Economic Analysis Questions and Input

Thank You